



This is a digital copy of a book that was preserved for generations on library shelves before it was carefully scanned by Google as part of a project to make the world's books discoverable online.

It has survived long enough for the copyright to expire and the book to enter the public domain. A public domain book is one that was never subject to copyright or whose legal copyright term has expired. Whether a book is in the public domain may vary country to country. Public domain books are our gateways to the past, representing a wealth of history, culture and knowledge that's often difficult to discover.

Marks, notations and other marginalia present in the original volume will appear in this file - a reminder of this book's long journey from the publisher to a library and finally to you.

Usage guidelines

Google is proud to partner with libraries to digitize public domain materials and make them widely accessible. Public domain books belong to the public and we are merely their custodians. Nevertheless, this work is expensive, so in order to keep providing this resource, we have taken steps to prevent abuse by commercial parties, including placing technical restrictions on automated querying.

We also ask that you:

- + *Make non-commercial use of the files* We designed Google Book Search for use by individuals, and we request that you use these files for personal, non-commercial purposes.
- + *Refrain from automated querying* Do not send automated queries of any sort to Google's system: If you are conducting research on machine translation, optical character recognition or other areas where access to a large amount of text is helpful, please contact us. We encourage the use of public domain materials for these purposes and may be able to help.
- + *Maintain attribution* The Google "watermark" you see on each file is essential for informing people about this project and helping them find additional materials through Google Book Search. Please do not remove it.
- + *Keep it legal* Whatever your use, remember that you are responsible for ensuring that what you are doing is legal. Do not assume that just because we believe a book is in the public domain for users in the United States, that the work is also in the public domain for users in other countries. Whether a book is still in copyright varies from country to country, and we can't offer guidance on whether any specific use of any specific book is allowed. Please do not assume that a book's appearance in Google Book Search means it can be used in any manner anywhere in the world. Copyright infringement liability can be quite severe.

About Google Book Search

Google's mission is to organize the world's information and to make it universally accessible and useful. Google Book Search helps readers discover the world's books while helping authors and publishers reach new audiences. You can search through the full text of this book on the web at <http://books.google.com/>



3 3433 06633245 7





Bowman

-250



(Bowman)

AN INTRODUCTION
TO
PRACTICAL CHEMISTRY,
INCLUDING ANALYSIS.

BY
JOHN E. BOWMAN,
DEMONSTRATOR OF CHEMISTRY IN KING'S COLLEGE, LONDON.



PHILADELPHIA:
LEA AND BLANCHARD.
1849.

"FACTS ARE THE MATERIALS OF SCIENCE; BUT ALL FACTS INVOLVE IDEAS. SINCE, IN OBSERVING FACTS, WE CANNOT EXCLUDE IDEAS, WE MUST, FOR THE PURPOSES OF SCIENCE, TAKE CARE THAT THE IDEAS ARE CLEAR, AND RIGOROUSLY APPLIED."

WHEWELL, *Philosophy of the Inductive Sciences*, vol. i. p. xxxvii.

PHILADELPHIA:
T. K. AND P. G. COLLINS PRINTERS.

P R E F A C E.

AMONG the many recent and valuable works on Chemistry, I am not aware of one having for its special object to explain and render simple to the beginner, the various processes employed in analysis, or which have been devised for the illustration of the principles of the Science. Most of them contain much that is superfluous for the general student, who has but a limited time to devote to the subject; while they are wanting in those explanatory details, without which he must often fail to understand the rationale of the operations through which he is conducted.

It is with a wish to supply this deficiency, and at the same time to furnish a text-book for my own classes, that the present little work has been written; and as it is intended for the use of those who have made but little progress in the Science, my endeavor has been throughout, to make everything as simple and intelligible as possible. The employment of complicated or expensive apparatus has been almost wholly avoided.

The outline of most of the First Part was arranged some years ago by my friend Professor Miller (at that time Demonstrator of Chemistry in King's College), for the use and direction of the class of Chemical Manipulation, then first established to supply a growing demand, and to meet the requirements of the University of London, and some of the other examining Boards of the Metropolis. In the compilation of the Second and Third Parts, I have been

much indebted to the excellent works of Rose, Fresenius, Parnell, and others ; I must also here thank my colleague, whose name I have already mentioned, for many valuable suggestions, and for his kindness in revising the proof sheets, without which assistance many errors would have crept in, and rendered the book less worthy of the student's confidence.

JOHN E. BOWMAN.

KING'S COLLEGE, LONDON,
September, 1848.

CONTENTS.

	PAGE
INTRODUCTION - - - - -	xiii.
Importance of Experimental Chemistry - - - - -	xiii.
Chemical Symbols and Equations - - - - -	xiv.
General Rules and Directions - - - - -	xix.

PART I.

CHAPTER I.

PNEUMATIC CHEMISTRY - - - - -	25
SECTION 1.—Hydrogen - - - - -	26
“ 2.—Carbonic acid - - - - -	28
“ 3.—Bin oxide of Nitrogen - - - - -	31
“ 4.—Olefiant gas - - - - -	32
“ 5.—Carbonic oxide - - - - -	33
“ 6.—Oxygen - - - - -	35
“ 7.—Hydrochloric acid gas - - - - -	37
“ 8.—Ammoniacal gas - - - - -	39

CHAPTER II.

DISTILLATION - - - - -	41
SECTION 1.—Water - - - - -	41
“ 2.—Hydrochloric acid - - - - -	45
“ 3.—Ammonia - - - - -	46
“ 4.—Nitric acid - - - - -	47

CHAPTER III.

GLASS WORKING - - - - -	48
-------------------------	----

CHAPTER IV.

EXPERIMENTS WITH THE MOUTH BLOWPIPE - - - - -	57
---	----

CHAPTER V.

SPECIFIC GRAVITY	-	-	-	-	-	PAGE
SECTION 1.—Of Solids heavier than water	-	-	-	-	-	65
“ 2.—Of solids lighter than water	-	-	-	-	-	66
“ 3.—Of Insoluble powders	-	-	-	-	-	67
“ 4.—Of Liquids	-	-	-	-	-	68

CHAPTER VI.

HEATING SUBSTANCES IN GASES	-	-	-	-	-	69
SECTION 1.—Reduction of Metallic Oxides by Hydrogen	-	-	-	-	-	69
“ 2.—Heating in an atmosphere of Carbonic acid	-	-	-	-	-	72
“ 3.—Preparation of Perchloride of Iron	-	-	-	-	-	73

CHAPTER VII.

ALKALIMETRY AND ACIDIMETRY	-	-	-	-	-	75
SECTION 1.—Alkalimetry	-	-	-	-	-	75
“ 2.—Acidimetry	-	-	-	-	-	78
“ 3.—Estimation of Carbonic acid in Carbonates	-	-	-	-	-	81



PART II.

THE ACTION OF REAGENTS ON BASES AND ACIDS.

CHAPTER I.

SECTION 1.—Introductory	-	-	-	-	-	83
“ 2.—Classification of Bases and Acids	-	-	-	-	-	84

CHAPTER II.

METALS BELONGING TO CLASS I.	-	-	-	-	-	86
SECTION 1.—Potash	-	-	-	-	-	87
“ 2.—Soda	-	-	-	-	-	88
“ 3.—Ammonia	-	-	-	-	-	89

CHAPTER III.

METALS BELONGING TO CLASS II.	-	-	-	-	-	92
SECTION 1.—Magnesia	-	-	-	-	-	92
“ 2.—Lime	-	-	-	-	-	94
“ 3.—Baryta	-	-	-	-	-	96
“ 4.—Strontia	-	-	-	-	-	98

CONTENTS.

xi

	PAGE
.....	246
.....	246
.....	247
.....	247
.....	247
.....	247
.....	248
.....	248
.....	248
.....	248
.....	249
.....	249

APPENDIX.

.....	251
.....	251
.....	251
.....	251
.....	251
.....	252
.....	252
.....	252
.....	252
.....	252
.....	253
.....	254
.....	255
.....	256
.....	257
.....	258
.....	259
.....	26
.....	2
.....	

PART III.

QUALITATIVE ANALYSIS OF SUBSTANCES, THE COMPOSITION
OF WHICH IS UNKNOWN.

CHAPTER I.

	PAGE
PRELIMINARY EXAMINATION, &c. - - - -	154
SECTION 1.—Preliminary Examination of Solids - -	155
“ 2.—Preliminary Examination of Liquids - -	160
“ 3.—Introductory Remarks on the Actual Analysis -	162

CHAPTER II.

QUALITATIVE ANALYSIS OF A SIMPLE SALT, WHICH IS SOLUBLE IN WATER - - - -	163
SECTION 1.—Examination for base - - - -	163
“ 2.—Examination for acid - - - -	168

CHAPTER III.

QUALITATIVE ANALYSIS OF A SIMPLE SALT, WHICH IS INSOLUBLE IN WATER, BUT SOLUBLE IN ACIDS - - - -	171
SECTION 1.—Examination for base - - - -	171
“ 2.—Examination for acid - - - -	174

CHAPTER IV.

QUALITATIVE ANALYSIS OF A SIMPLE SALT, WHICH IS INSOLUBLE BOTH IN WATER AND ACIDS - - - -	176
--	-----

CHAPTER V.

QUALITATIVE ANALYSIS OF A MIXTURE OF TWO OR MORE SALTS, WHICH MAY CONTAIN ALL THE BASES AND ACIDS IN THE LIST. INTRODUCTORY REMARKS - - -	178
---	-----

CHAPTER VI.

QUALITATIVE ANALYSIS OF A MIXTURE OF SALTS, SOLUBLE IN WATER - - - -	180
SECTION 1.—Examination for bases - - - -	180
“ 2.—Examination for acids - - - -	189

CONTENTS.

ix

CHAPTER VII.

	PAGE
QUALITATIVE ANALYSIS OF A MIXTURE OF SALTS, INSOLUBLE IN WATER, BUT SOLUBLE IN ACIDS - - -	192
SECTION 1.—Examination for bases - - -	192
“ 2.—Examination for acids - - -	194

CHAPTER VIII.

QUALITATIVE ANALYSIS OF A MIXTURE OF SALTS, INSOLUBLE IN WATER AND ACIDS - - -	196
--	-----



PART IV.

QUANTITATIVE ANALYSIS.

INTRODUCTORY REMARKS - - -	198
----------------------------	-----

CHAPTER I.

OPERATIONS IN ANALYSIS - - -	199
Pulverization - - -	199
Drying - - -	199
Weighing - - -	200
Solution - - -	200
Precipitation - - -	202
Filtration - - -	202
Decantation - - -	207
Evaporation - - -	207
Ignition - - -	210
Calculation of results - - -	212

CHAPTER II.

EXAMPLES OF QUANTITATIVE ANALYSIS - - -	212
SECTION 1.—Quantitative Analysis of Sulphate of Copper -	213
“ 2.—Quantitative Analysis of Chloride of Potassium -	214
“ 3.—Quantitative Analysis of a Mixture of Sulphate of Copper and Chloride of Sodium -	216
“ 4.—Quantitative Analysis of a Mixture of Sulphate of Zinc and Carbonate of Baryta -	218
“ 5.—Quantitative Analysis of Magnesian Limestone -	220
“ 6.—Quantitative Analysis of Copper Pyrites -	223

PART V.

CHAPTER I.

EXAMINATION OF CALCULI	-	-	-	-	-	-	PAGE
SECTION 1.—Uric acid	-	-	-	-	-	-	25
“ 2.—Urate of Ammonia	-	-	-	-	-	-	25
“ 3.—Phosphate of Lime	-	-	-	-	-	-	25
“ 4.—Triple Phosphate	-	-	-	-	-	-	25
“ 5.—Fusible Calculus	-	-	-	-	-	-	25
“ 6.—Oxalate of Lime	-	-	-	-	-	-	25
“ 7.—Biliary	-	-	-	-	-	-	25

CHAPTER II.

REAGENTS	-	-	-	-	-	-	PAGE
Sulphuric acid	-	-	-	-	-	-	25
Hydrochloric acid	-	-	-	-	-	-	25
Nitric acid	-	-	-	-	-	-	25
Nitrohydrochloric acid (aqua regia)	-	-	-	-	-	-	25
Hydrosulphuric acid	-	-	-	-	-	-	25
Oxalic acid	-	-	-	-	-	-	25
Acetic acid	-	-	-	-	-	-	25
Tartaric acid	-	-	-	-	-	-	25
Ammonia	-	-	-	-	-	-	25
Hydrosulphate of Ammonia	-	-	-	-	-	-	25
Carbonate of Ammonia	-	-	-	-	-	-	25
Oxalate of Ammonia	-	-	-	-	-	-	25
Phosphate of Soda and Ammonia	-	-	-	-	-	-	25
Potash	-	-	-	-	-	-	25
Carbonate of Potash	-	-	-	-	-	-	24
Nitrate of Potash	-	-	-	-	-	-	24
Iodide of Potassium	-	-	-	-	-	-	24
Chromate of Potash	-	-	-	-	-	-	24
Cyanide of Potassium	-	-	-	-	-	-	24
Ferrocyanide of Potassium	-	-	-	-	-	-	24
Ferridecyanide of Potassium	-	-	-	-	-	-	24
Antimoniate of Potash	-	-	-	-	-	-	24
Carbonate of Soda	-	-	-	-	-	-	24
Phosphate of Soda	-	-	-	-	-	-	24
Borax	-	-	-	-	-	-	24
Lime water	-	-	-	-	-	-	24
Sulphate of Lime	-	-	-	-	-	-	24
Chloride of Calcium	-	-	-	-	-	-	24
Chloride of Barium	-	-	-	-	-	-	24
Nitrate of Baryta	-	-	-	-	-	-	24
Perchloride of Iron	-	-	-	-	-	-	24
Nitrate of Cobalt	-	-	-	-	-	-	24
Sulphate of Copper	-	-	-	-	-	-	24

CONTENTS.

xi

REAGENTS—continued.	PAGE
Acetate of Lead - - - - -	246
Subacetate of Lead - - - - -	246
Nitrate of Silver - - - - -	247
Ammonio-nitrate of Silver - - - - -	247
Perchloride of Mercury - - - - -	247
Protochloride of Tin - - - - -	247
Perchloride of Gold - - - - -	248
Bichloride of Platinum - - - - -	248
Sulphate of Indigo - - - - -	248
Starch - - - - -	248
Black Flux - - - - -	248
Distilled Water - - - - -	249
Alcohol - - - - -	249

APPENDIX.

WEIGHTS AND MEASURES - - - - -	251
Troy or Apothecaries' Weight - - - - -	251
Avoirdupois Weight - - - - -	251
Imperial Measure - - - - -	251
Weight of Water contained in the Imperial Measure - - - - -	251
Cubic inches contained in the Imperial Measure - - - - -	252
FRENCH WEIGHTS AND MEASURES - - - - -	252
Measures of length - - - - -	252
Measures of capacity - - - - -	252
Measures of weight - - - - -	252
Table showing the strength of Sulphuric acid of different densities - - - - -	253
Table showing the strength of Nitric acid of different densities - - - - -	254
Table showing the strength of Hydrochloric acid of different densities - - - - -	255
Table showing the strength of Solution of Potash of different densities - - - - -	256
Table showing the strength of Solution of Soda of different densities - - - - -	257
Table showing the strength of Liquid Ammonia of different densities - - - - -	257
Table showing the strength of Alcohol of different densities - - - - -	259
Table showing the strength of Ether of different densities - - - - -	259
Table of Freezing Mixtures' - - - - -	260
Table showing the corresponding degrees on the Centigrade and Fahrenheit's Thermometers - - - - -	282
Table showing the Solubility of Salts - - - - -	284

Table showing the action of Reagents on Oxides and Acids	PAGE
Table showing the behavior of Solutions of the Metals with Hydro-sulphuric Acid, Hydrosulphate of Ammonia, and Carbonate of Ammonia	26
List of Salts, &c., which may be examined for practice in Qualitative Analysis	27
Glossary of Chemical Terms	28
Index	29

INTRODUCTION.

1. So essentially is chemistry an experimental science, and so almost exclusively is it built up of facts which have been elucidated by experiment, that without experimental illustrations it would be quite impossible to teach or to study it with any great amount of success. It is not enough, however, for the student to see experiments performed by others; he must, if he would master even the general principles of chemistry, learn to make experiments himself; and he will, probably, be surprised how much more easily he will retain in his recollection those phenomena (as well as the principles they illustrate) which his own hands have been the means of producing. This is especially the case when he is enabled, while operating in the laboratory, to learn and study the theory of the changes which take place under his direction.

2. With the view of enabling the beginner to do this as much as possible, I have in the following pages explained, by means of chemical symbols and equations, nearly the whole of the changes and decompositions which take place in the experiments described. The symbols which I have made use of are those now almost universally adopted by chemists; and it will be seen by the following Table, that they consist, for the most part, of the first letter or two letters of the Latin names of the elements which they express.

Table of Elementary Substances (arranged alphabetically), showing their symbols, atomic weights, and the composition of some of their compounds.

Name.	Symbol.	Atomic Weight.	Compounds.
Aluminum . . .	Al	14	{ Al_2O_3 Alumina. Al_2Cl_3 Chloride of aluminum. $Al_2O_3 \cdot 3SO_3$ Sulphate of alumina.
Antimony . . .	Sb	129	{ Sb_2O_3 Oxide of antimony. Sb_2O_4 Antimonious acid. Sb_2O_5 Antimonic acid.
Arsenic . . .	As	75	{ As_2O_3 Arsenious acid. As_2O_5 Arsenic acid.
Barium . . .	Ba	60	{ BaO Baryta. $BaCl_2$ Chloride of barium.
Bismuth . . .	Bi	107	{ Bi_2O_3 Oxide of bismuth. $Bi_2O_3 \cdot 3NO_5$ Nitrate of bismuth. Bi_2Cl_3 Chloride of bismuth.
Boron . . .	B	11	{ BO_2 Boracic acid.
Bromine . . .	Br	78	{ Br_2O_5 Bromic acid. HBr Hydrobromic acid.
Cadmium . . .	Cd	56	{ CdO Oxide of cadmium. CdS Sulphide of cadmium.
Calcium . . .	Ca	20	{ CaO Lime. $CaCl_2$ Chloride of calcium.
Carbon . . .	C	6	{ CO Carbonic oxide. CO_2 Carbonic acid. CS_2 Sulphide of carbon.
Cerium . . .	Ce	46	{ CeO Oxide of cerium. Ce_2O_3 Sesquioxide of cerium.
Chlorine . . .	Cl	36	{ ClO_5 Chloric acid. ClO_7 Perchloric acid. HCl Hydrochloric acid.
Chromium . . .	Cr	28	{ Cr_2O_3 Chromic acid. Cr_2O_3 Oxide of chromium. $Cr_2O_3 \cdot 3SO_3$ Sulphate of chromium
Cobalt . . .	Co	30	{ CoO Oxide of cobalt. Co_2O_3 Sesquioxide of cobalt.
Copper . . . (Cuprum).	Cu	32	{ Cu_2O Suboxide of copper. CuO Black oxide of copper. $CuO \cdot SO_3$ Sulphate of copper.
Didymium . . .	D	?	{ ?
Fluorine . . .	F	18	{ HF Hydrofluoric acid. BF_3 Fluoboric acid.
Glucinum . . .	G	7(?)	{ GO_5 Glucina. GCl_5 Chloride of glucinum.
Gold . . . (Aurum).	Au	200	{ AuO Oxide of gold. Au_2O_3 Teroxide of gold. $AuCl_3$ Trichloride of gold.
Hydrogen . . .	H	1	{ HO (or Aq) Water. HO_2 Binoxide of hydrogen.

Name.	Symbol.	Atomic Weight.	Compounds.
Iodine	I	126	{ IO_5 Iodic acid. HI Hydriodic acid.
Iridium	Ir	99	{ IrO Protoxide of iridium. Ir_2O_3 Sesquioxide of iridium.
Iron (Ferrum).	Fe	28	{ FeO Protoxide of iron. Fe_2O_3 Sesquioxide of iron.
Lanthanum . . .	Ln	48	{ LnO Oxide of lanthanum.
Lead (Plumbum).	Pb	104	{ PbO Protoxide of lead. Pb_2O_4 Red oxide of lead. PbCl Chloride of lead.
Lithium	Li	7	{ LiO Lithia. LiCl Chloride of lithium.
Magnesium . . .	Mg	12	{ MgO Magnesia. MgCl Chloride of magnesium.
Manganese . . .	Mn	28	{ MnO Protoxide of manganese. MnO_2 Binoxide or black oxide. Mn_2O_3 Manganic acid. Mn_2O_7 Permanganic acid.
Mercury	Hg	202	{ HgO Protoxide of mercury. HgO_2 Red oxide of mercury. HgCl Protochloride of mercury. HgCl_2 Perchloride of mercury.
Molybdenum . . .	Mo	48	{ MoO_3 Molybdic acid.
Nickel	Ni	30	{ NiO Oxide of nickel. Ni_2O_3 Sesquioxide of nickel.
Nitrogen	N	14	{ NO_5 Nitric acid. NO_2 Binoxide of nitrogen. NH_3 Ammonia.
Osmium	Os	99	{ OsO_4 Osmic acid. OsO_2 Binoxide of osmium.
Oxygen	O	8	
Palladium	Pd	54	{ PdO Protoxide of palladium. PdO_2 Peroxide of palladium.
Phosphorus . . .	P	32	{ PO_5 Phosphoric acid. PO_3 Phosphorous acid. PH_3 Phosphuretted hydrogen.
Platinum	Pt	99	{ PtO Protoxide of platinum. PtO_2 Binoxide of platinum.
Potassium . . . (Kalium).	K	40	{ KO Potash. KCl Chloride of potassium.
Rhodium	R	52	{ RO Protoxide of rhodium.
Ruthenium	Ru	52	{ R_2O_3 Sesquioxide of rhodium. Ru_2O_3 Sesquioxide of ruthenium.
Selenium	Se	40	{ SeO_2 Selenic acid. HSe Hydroselenic acid.
Silicon	Si	22	{ SiO_2 Silicic acid.
Silver (Argentum).	Ag	108	{ AgO Oxide of silver. AgCl Chloride of silver.
Sodium (Natronium).	Na	24	{ NaO Soda. NaCl Chloride of sodium.

Name.	Symbol.	Atomic Weight.	Compounds.
Strontium . . .	Sr	44	{ SrO Strontia. { SrCl Chloride of strontium.
Sulphur . . .	S	16	{ SO ₃ Sulphuric acid. { HS Hydrosulphuric acid.
Tantalum . . . (or Columbium)	Ta	185	{ TaO ₃ Oxide of tantalum. { TaO ₆ Tantalac acid. { TeO ₃ Telluric acid.
Tellurium . . .	Te	64	{ HTe ₃ Hydrotelluric acid.
Thorium . . .	Th	60	{ ThO Oxide of thorium.
Tin (Stannum).	Sn	59	{ ThCl Chloride of thorium. { SnO Protoxide of tin. { SnO ₂ Peroxide of tin.
Titanium . . .	Ti	24	{ TiO Titanic acid.
Tungsten . . . (Wolfram).	W	96	{ TiCl ₂ Bichloride of titanium. WO ₃ Tungstic acid.
Uranium . . .	U	60	{ UO Protoxide of uranium.
Vanadium . . .	V	69	{ U ₂ O ₃ Sesquioxide of uranium. VO ₃ Vanadic acid.
Yttrium . . .	Y	32	{ YO Ytria. { YCl Chloride of Yttrium.
Zinc	Zn	32	{ ZnO Oxide of zinc. { ZnCl Chloride of zinc.
Zirconium . . .	Zr	34	{ Zr ₂ O ₃ Zirconia. { ZrCl ₃ Chloride of zirconium.

3. Each of these symbols expresses one equivalent or atom of the substance which it represents. Thus H stands for one atom or equivalent of hydrogen; Cu for an equivalent of copper; Hg for one of mercury.

When a small figure is placed to the right of a symbol, rather below the line, it means that there is that number of equivalents of the substance present. Thus Pb_2 means two equivalents of lead; O_5 , five equivalents of oxygen; H_{10} , ten equivalents of hydrogen.

Two or more symbols placed together, signify that the elements which they represent are chemically united in the closest manner. Thus HO stands for water, which is a compound of one equivalent of hydrogen and one of oxygen; SO_3 represents anhydrous sulphuric acid, composed of one equivalent of sulphur and three of oxygen; $C_{12}H_{10}O_{10}$

represents starch, which consists of 12 equivalents of carbon, 10 of hydrogen, and 10 of oxygen, chemically combined together.

When symbols are separated by a comma, they represent compounds which are held together by a force less strong than that which unites elements that have no such mark interposed. Thus KO, SO_3 means sulphate of potash, composed of potash and sulphuric acid. The constituents of sulphate of potash, therefore, are both compounds, and the affinity which unites the potassium with the oxygen, and the sulphur with the three equivalents of the same element, is supposed to be stronger than that which unites the acid with the base, since it is easier to break it up into potash and sulphuric acid, than into potassium, oxygen, and sulphur.

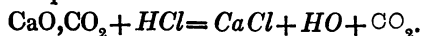
When the sign $+$ is interposed, it indicates that the substances between which it is placed are united in a manner still less intimate. Thus in crystallized carbonate of soda ($\text{NaO}, \text{CO}_2 + 10\text{Aq}$), we have sodium and oxygen in the soda, and carbon and oxygen in the carbonic acid, combined in the closest and strongest manner; the soda and carbonic acid thus formed are separated by a comma, showing that they are held together by what we may here call the second degree of affinity; while the 10 equivalents of water of crystallization, separated by the sign $+$, are held by a much weaker force, so feeble indeed that a very moderate heat is sufficient to expel them.

The sign $+$ is used also to separate the symbols of substances which are entirely disunited, as when we wish to express a mixture of carbonate of lime and hydrochloric acid, we put it thus, $\text{CaO}, \text{CO}_2 + \text{HCl}$.

A large figure placed immediately before a symbol, multiplies all the symbols as far as the next comma or $+$ sign. Thus, in the common phosphate of soda ($2\text{NaO}, \text{HO}, \text{PO}_3$),

there are two equivalents of soda, one of water, and one of phosphoric acid, combined together. If a large figure were placed before the whole formula enclosed in brackets, thus, $5(2\text{NaO}, \text{HO}, \text{PO}_5)$, it would represent 5 equivalents of the entire salt.

4. It is really wonderful how much these little symbols are capable of expressing, and how often and completely they assist in simplifying and rendering intelligible even the most complicated chemical changes; for besides the information they convey relative to the composition of the substances which they express, they can be so combined in the form of equations, as to show in the most perfect manner, the various compounds which result during chemical decompositions. For this purpose, the symbols of the substances employed are placed together so as to form one side of the equation; on the other side are placed those of the substances which are produced during the decomposition; and as no atom of matter is lost during these transformations, it necessarily follows that the value of both sides of the equation must be equal. For example, the decomposition of carbonate of lime by hydrochloric acid, may be thus represented:—



Here we place the symbols of carbonate of lime and hydrochloric acid on one side, and on the other those of chloride of calcium, water, and carbonic acid, which are produced during the decomposition; and it will be observed that on each side there are exactly the same number of equivalents, viz. 1 of calcium, 3 of oxygen, 1 of carbon, 1 of hydrogen, and 1 of chlorine.

5. I have ventured to introduce a slight modification of the usual mode of printing the symbols, which will enable the student to see at a glance whether the substances expressed, are in the solid, liquid, or gaseous form.

Those in the solid state are printed in strong Roman type, as Pb, lead. Liquids, as substances in solution, are printed in strong italics, as *HO*, water; and gases or vapors are represented by thin letters, as H, hydrogen. HO , steam.

Thus in the above equation, liquid hydrochloric acid (*HCl*) is poured on solid carbonate of lime (CaO, CO_2); chloride of calcium (*CaCl*) is formed, which remains in solution, together with carbonic acid (CO_2), which passes off in the gaseous form.

6. It is very important that the student should at once begin to make careful notes of all the experiments he engages in. He should endeavor to do this in as concise and methodical a manner as possible, and he will find it very advantageous to make use of symbols in describing the substances he employs, and the changes which they undergo: he will thus be able to record much in a small space, and at the same time he will be making himself familiar with the composition of the substances with which he is experimenting.

7. When, as is often the case, especially in analytical experiments, there are several solutions and precipitates either filtering, digesting, or waiting till the operator has leisure to attend to them, it is necessary to mark them in some way, to prevent confusion. This is easily done with small pieces of gummed paper, on which a letter or number may be written, corresponding with a similar reference mark in the note book.

8. The student will soon learn by experience that he cannot be too methodical in his operations, or too careful in cultivating habits of neatness and cleanliness. The presence of a little saline or other impurity in a glass, owing to careless washing, or a little extraneous matter having

been allowed to find its way into a bottle or test-tube, may retard or spoil the result of whole days of labor.

“Much as the chemist may soil his fingers during his experimental occupations, he will soon learn the great importance of cleanliness to the success of his experiments. The regular course of his operations causes many kinds of matter to pass in succession through his hands; and many of the substances, which by mixture have exhibited the phenomena they were competent to occasion, and so far answered the purpose of the experiment, then become mere useless dirt. Their dismissal and entire removal when thus circumstanced become necessary, that they may not contaminate other bodies; and are as imperatively required, as was the care previously bestowed to prevent their contamination from extraneous matter.

“It is this rapid change in the character and relation of the substances with which the chemist works, that makes a constant attention to cleanliness essentially necessary. The very bodies which at one moment are carefully retained in vessels that have previously been cleansed with the most scrupulous attention, become the next in the situation of so much dirt, from which the vessels must be cleansed as perfectly and carefully, before they can be fit for another experiment, as they were for the reception of the now rejected matter. The results of numerous experiments relative to testing bodies in solution by reagents, are in many cases dependent on the employing of clean vessels. For instance, a portion of water examined in glasses which have been carelessly washed, may occasion a slight precipitate with nitrate of silver or chloride of barium and thus seem to contain a chloride or a sulphate (403, 429), when the cause of the precipitate may be nothing more than portions of salts adhering to the vessel.

“In the same manner the purity of an acid or a test, is

not unfrequently affected by the state of the bottle containing it, or by the dirty condition of glass rods dipped into it, or of the funnels through which it has been poured, or filtered, or of the vessels used in its transference; and sometimes it is contaminated by laying the stopper of the bottle containing it in a dirty place. Nor is it only that kind of dirt or impurity which gives an evident tinge to what it adheres to, that is to be avoided, but also numerous colorless substances, as salts, solutions, &c.; and in a word, anything which differs from the principal substance itself, and is at the same time liable to be dissolved or mixed with it.

“In consequence of these liabilities, and their interference with experiments, it should be established as a general rule in the laboratory, that no apparatus, nor any vessel, (except such as may be destined to a particular use, and is as convenient when with a little previously adhering matter as if it were clean,) be put away in a dirty state. All vessels or instruments when resorted to, should be found fit for the nicest experiment to which they are applicable. Glass rods or stirrers should be preserved in a clean place; glasses, on a clean shelf; and stoppers, when taken out of bottles, should be laid upon clean surfaces. These attentions and regulations will be found always useful, at times essential; and they are generally more requisite and influential in minute chemistry, than in large experiments.”*

9. It is easy to clean even the dirtiest vessel, provided it has not been allowed to remain long with the impurities adhering to it; this, indeed, should never be permitted, and is readily avoided by making it a rule never to leave work for the day until the whole of the soiled apparatus has been thoroughly washed, and left to drain during the

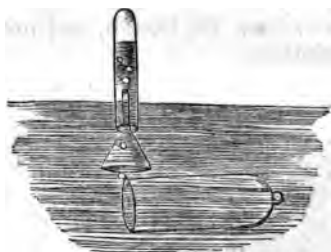
* Faraday's Chemical Manipulation, p. 323.

jar after the combustion, which is the water formed by the combination of the hydrogen with oxygen. $H + O = HO$.

14. Fill a small jar with the gas, and having removed it from the gas-holder, let it stand for a few seconds with its open end upwards. If a lighted taper be now applied, no combustion will ensue, as the hydrogen will have escaped upwards, on account of its very low specific gravity.

15. Repeat the last experiment, holding the jar with the open end *downwards*. On applying a lighted taper, a slight explosion will take place, showing that the hydrogen had not escaped as before,

Fig. 5.



16. Transfer some of the gas from a large jar to a small one, and from this again to tubes, until it can be done without allowing any bubbles to escape. When the gas is to be decanted into a jar or tube which is much narrower, it may be first transferred into a lipped glass, or an inverted funnel may be used.

17. Transfer a little of the hydrogen in this way into a graduated tube, and mix it with varying but definite portions of common air; then ascertain by experiment what proportions detonate most loudly when a lighted taper is applied. The jars used for these experiments should be small and strong, to avoid risk of fracture by the force of the explosion.

SECTION II.

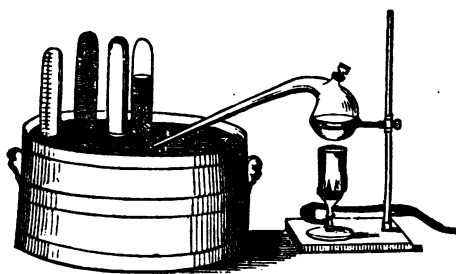
*Preparation of Carbonic Acid (CO_2).**

18. As this gas is to a considerable extent soluble in water, it is better in its preparation not to use the gas-

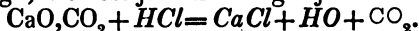
* The specific gravity of carbonic acid is 1.524 (air being 1.0), 100 cubic inches weighing 47.26 grains. Its atomic weight is 22; and its combining volume 1. At a temperature of 60° water dissolves about its own bulk of carbonic acid.

holder, on account of the large quantity of water it would then have to pass through, but to collect it at once in jars over the pneumatic trough.

Fig. 6.

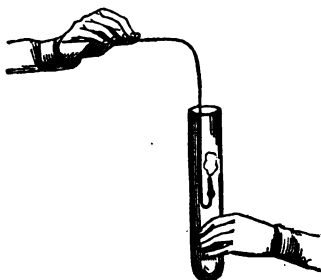


19. Put 300 grains of marble (CaO, CO_2) broken into fragments about the size of a pea, into a retort, observing the same precautions as were recommended in the preparation of hydrogen (12). Measure out an ounce and a half of hydrochloric acid (HCl), dilute it with an equal quantity of water, and pour the mixture upon the marble. The gas is immediately given off, causing brisk effervescence, and it may be collected in jars placed on the shelf of the pneumatic trough, the first jar full being rejected as impure.



20. Introduce a lighted taper into a small jar of the gas held with its open end upwards. It is instantly extinguished; and as the carbonic acid remains some time in the jar, on account of its high specific gravity, the taper may be extinguished repeatedly in the same jar full of gas.

Fig. 7.



21. Pour a little lime-water (CaO) into a test-glass and thence into a jar filled with the gas, closing the mouth of the jar with a glass plate, and agitating the

gas and liquid together. The lime-water almost immediately becomes milky, owing to the formation of carbonate of lime (CaO, CO_2) which is insoluble in water.

If a few drops of hydrochloric acid (HCl) be added, the carbonate of lime is decomposed, and the milkiness disappears, chloride of calcium being formed, which is soluble in water.

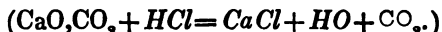
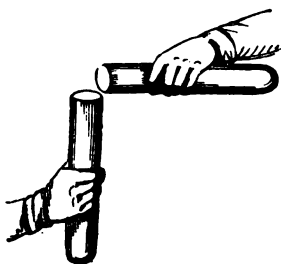


Fig. 8.

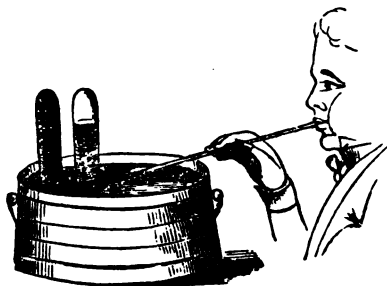


22. Having filled a jar with the gas, pour it like water, into another jar somewhat smaller; this is easily effected, owing to the high specific gravity of carbonic acid. Test its presence in both jars with lime-water, and by its power of extinguishing a taper.

23. The high specific gravity of carbonic acid, and its power of extinguishing flame, may be strikingly shown by pouring it from a jar upon a lighted candle, which is instantly put out.

24. By means of a narrow tube open at both ends, fill a jar over the pneumatic trough, with air from the lungs.

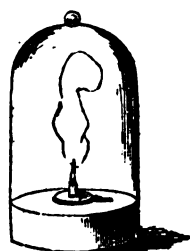
Fig. 9.



Test it with a lighted taper, and observe that it causes an abundant precipitate in lime-water, owing to the presence of carbonic acid.

25. Invert a jar filled with common air over a lighted taper floating on the water of the pneumatic trough, and observe that it soon burns dim, and is shortly extinguished, the water at the same time slowly rising in the jar.* When the combustion is over, invert the jar, and test the air contained in it with lime-water for carbonic acid.

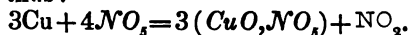
Fig. 10.



SECTION III.

Preparation of Binoxide of Nitrogen (NO₂).†

26. Put 300 grains of copper turnings into a retort, and pour upon it an ounce and a half of strong nitric acid (NO₃) previously diluted with an equal quantity of water. Decomposition immediately commences, and the binoxide is formed by the action of the copper on a portion of the nitric acid, thus:—



The gas which is first formed becomes orange, owing to its conversion into nitrous acid (NO₂) by combining with the atmospheric oxygen contained in the retort (NO₂ + 2 O = NO₄).

27. Transfer a little to a jar, and test it with a taper; observe the orange fumes of nitrous acid which are instantly produced wherever the gas mixes with the air.

28. Measure a definite quantity of the gas in a graduated receiver, and transfer it to another jar over the pneumatic trough: then measure off an equal volume of atmospheric air, and add it by decantation, to the binoxide. When the orange fumes have disappeared, owing to the absorption of the nitrous acid by the water, transfer it again to the gra-

* The absorption of air and consequent rising of the water in the jar, is here owing to the disappearance of the oxygen, which combines with the hydrogen and carbon of the burning wax. Nearly one-fifth of the air is thus condensed, that being the proportion of oxygen contained in the atmosphere; the remaining four fifths are nitrogen.

† The specific gravity of binoxide of nitrogen is 1.039, 100 cubic inches weighing 32.22 grains. Its atomic weight is 30.00 and its combining volume 2.

duated jar, and observe the volume of the mixture, noticing accurately the difference between this and the sum of the original volumes employed before mixing. This experiment should be repeated three or four times, and if the results in each case agree pretty closely, take the average of the experiments, and the amount of condensation, divided by three, will give very nearly the quantity of oxygen contained in the atmospheric air employed. One equivalent of binoxide of nitrogen occupying two volumes, when combined with two equivalents of oxygen occupying one volume, forms one equivalent of nitrous acid (NO_2) which is absorbed by the water; consequently one-third of the gas absorbed consists of atmospheric oxygen.

Though the results obtained in this way are not very accurate, owing to the formation of other oxides of nitrogen, they are sufficiently so to allow of its occasional employment in determining the quantity of free oxygen in a gaseous mixture; and also when the whole of the uncombined oxygen has to be removed from a mixture containing it.

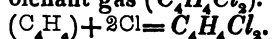
SECTION IV.

*Preparation of Olefiant Gas (C_4H_4).**

29. Pour into a retort six fluidrachms of alcohol ($\text{C}_4\text{H}_8\text{O}, \text{HO}$) and add to it in small portions an ounce and a half of strong sulphuric acid (HO, SO_3) gently agitating the mixture after each addition. Apply a moderate heat, and take care that the black froth which is formed towards the close of the operation, does not boil over. Collect the gas in jars over the pneumatic trough, or in the gas-holder.

30. Examine a small jar full with a taper, and observe that, though the taper is extinguished, the gas burns with a bright white flame.

31. When mixed with an equal volume of chlorine (Cl) the two gases combine, forming a heavy oily compound called chloride of olefiant gas ($\text{C}_4\text{H}_4\text{Cl}_2$).

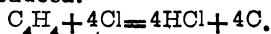


* The specific gravity of olefiant gas is 0.981, 100 cubic inches weighing 30.57 grains. Its atomic weight is 14, and its atomic volume 2.

The oil collects in drops on the sides of the jar and on the surface of the water, while the gases are gradually absorbed.

Olefiant gas derives its name from the circumstance of its forming this oily compound.

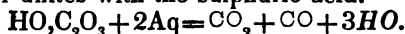
32. Mix together one volume of olefiant gas and two volumes of chlorine; close the jar with a glass valve, and quickly remove it from the pneumatic trough. Apply a light to the mixed gases, and observe the dense cloud of carbonaceous matter that is formed as the combustion gradually passes down the jar, hydrochloric acid being at the same time produced.



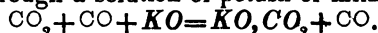
SECTION V.

*Preparation of Carbonic Oxide (CO).**

33. Carbonic oxide is prepared by the action of strong sulphuric acid (HO, SO_3) on oxalic acid ($HO, C_2O_3 + 2Aq$). When a mixture of the two acids is warmed, the oxalic is resolved into carbonic acid, carbonic oxide, and water, which latter unites with the sulphuric acid.



The carbonic oxide is purified from the carbonic acid by passing it through a solution of potash or milk of lime.



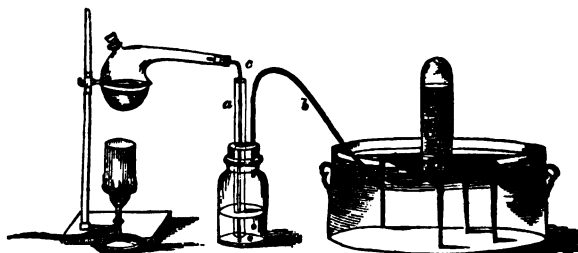
34. Adapt a cork to a wide-mouthed bottle capable of holding half a pint of water, and fit to it two tubes (152), one of which *a*, should be about half an inch in diameter, straight, and sufficiently long to reach nearly to the bottom; the other *b*, should only just pierce through the cork, and should be bent so as to deliver the gas, as shown in the figure; the diameter of this tube need not be more than about $\frac{1}{8}$ of an inch.

The beak of the retort may now be fitted with a cork, which should be bored to allow the bent tube *c* to pass through it; and care must be taken that this tube is suffi-

* The specific gravity of carbonic oxide is 0.973, 100 cubic inches weighing 30.21 grains. Its atomic weight is 14.0, and its atomic volume 1.

ciently small to slide easily down the tube *a*, and long enough to reach the bottom of the bottle.

Fig. 11.



Four ounces of a tolerably strong solution of potash (*KO*) may now be introduced into the bottle.

35. Charge the retort with 180 grains of crystallized oxalic acid ($\text{HO}, \text{C}_2\text{O}_3 + 2\text{Aq}$) and two fluid ounces of strong sulphuric acid (HO, SO_3). On applying a gentle heat, the gas is given off, the first portions of which must be rejected as impure, and then two or three jars full may be collected over the pneumatic trough before the bottle containing the potash is connected with the retort. The gas thus obtained is a mixture of carbonic acid and carbonic oxide (33).

36. Having collected two or three jars full of the mixed gases for comparison, adapt the bent tube *c* to the mouth of the retort, and proceed to purify the gas from carbonic acid by passing it through the alkaline solution in the bottle. Pure carbonic oxide may then be collected.

37. Agitate a little lime-water with a jar full of the unpurified gas; the presence of carbonic acid is shown by the formation of carbonate of lime (21).

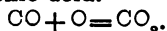
38. Repeat the experiment with a jar full of the purified gas. No precipitate ought now to appear.

39. Apply a lighted taper to a jar full of the impure gas, and observe the characteristic pale blue flame with which the carbonic oxide burns.

40. Do the same with a jar of the pure gas: the flame is brighter than when carbonic acid was present.

41. Pour a little lime-water into the jar used in the last

experiment immediately after the combustion of the gas. The white precipitate which now appears, and which was not formed when the same gas was tested previous to the combustion, shows the result of that process to have been the formation of carbonic acid.



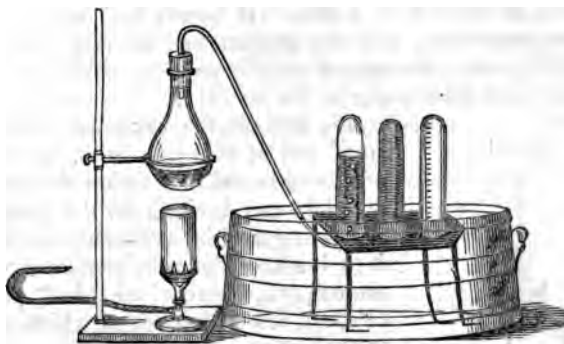
SECTION VI.

*Preparation of Oxygen (O).**

42. Adapt a bent tube of the form shown in the figure, to a small hard glass flask, by means of a perforated cork.

Then weigh 100 grains of dried chlorate of potash (KO, ClO_3), mix it with 20 grains of black oxide of manganese (MnO_2), and place the mixture in the flask; adjust the tube so as to deliver the gas into the gas-holder, or

Fig. 12.

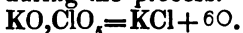


under the shelf of the pneumatic trough, and apply the heat of a lamp.

The chlorate of potash is thus decomposed, and gradually gives off the whole of its oxygen, which passes out through the tube, and may be collected either in the gas-holder or in jars, while chloride of potassium (KCl) remains

* The specific gravity of oxygen is 1.1057, 100 cubic inches weighing 34.29 grains. Its atomic weight is 8, and its combining volume $\frac{1}{2}$.

in the flask, together with the oxide of manganese, which is not decomposed during the process.*



The first portions of the gas should be rejected as impure, being mixed with the common air contained in the flask and tube.

43. The jars used for the following experiments should be open both at the top and bottom, the edges of both being ground smooth, so as to be closed air-tight with a glass valve *b*.



44. Fill a jar with the gas, and introduce a glowing taper; it will instantly burst into flame, and burn with great brilliancy, until most of the oxygen is exhausted, by combining with the carbon and hydrogen of the wax.

45. Introduce into another jar of the gas a small piece of ignited charcoal, attached to the end of a wire. It bursts into vivid combustion, combining with the oxygen, and forming carbonic acid (CO_2), the presence of which may be proved by agitating a little lime-water in the jar (21).



46. Repeat the experiment with a small coil of thin iron wire, to which a little charcoal or amadou should be attached and ignited, for the purpose of heating the iron sufficiently to cause it to burn. The iron combines with the oxygen, forming the black oxide (Fe_3O_4), fused globules of which drop to the bottom, and should be received in water, as they are so intensely hot as to fuse into the glaze of a plate if allowed to fall upon it.

47. Place a fragment of sulphur about the size of a pea in the deflagrating spoon, set it on fire by holding

* The oxide of manganese is here used, because it is found that, when thus mixed, chlorate of potash gives off its oxygen with much greater facility and at a lower temperature than when heated alone.

it over a lamp, and introduce it into a jar of the gas; the sulphur burns with a brilliant blue flame, combining with the oxygen, and forming sulphurous acid (SO_2).

48. Mix together two volumes of hydrogen and one of oxygen, and fill a small jar or tube, which for this experiment should be made of thick glass. On applying a light the gases combine with a loud explosion, forming water.
 $\text{H} + \text{O} = \text{HO}$.

SECTION VII.

Preparation of Gases which are soluble in Water.

49. Although in the preparation of many of the common gases, it is most convenient to collect them over water, either in the gas-holder, or in jars placed in the pneumatic trough, still there are many cases in which this method is inapplicable, as when the gas is to any considerable extent soluble in water. It is usual in such cases, especially when great purity is necessary, to collect them in tubes or jars over mercury, which is not acted upon by the majority of the gases. For common purposes, however, some of them may be collected by the displacement of common air from dry bottles, and the more the gas differs in density from atmospheric air, the more is this method applicable.

Hydrochloric acid gas and ammonia, may be taken as examples of the process.

*Preparation of Hydrochloric Acid Gas (HCl).**

50. This gas is easily obtained by the action of sulphuric acid on common salt.

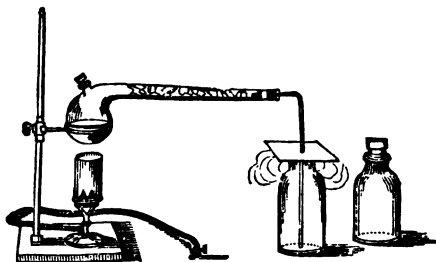
To the beak of a retort, a bent tube of the form represented in the figure, is adapted by means of a perforated cork, a loose roll of filtering paper is introduced into the neck, to retain any moisture that may distil over; and the retort is charged by introducing 300 grains of dry chloride of sodium (NaCl), and adding to it six fluid-

* The specific gravity of hydrochloric acid gas is 1.269, 100 cubic inches weighing 39.37 grains. Its atomic weight is 37, and its atomic volume 1.

38 PREPARATION OF HYDROCHLORIC ACID GAS.

drachms of strong sulphuric acid (HO,SO_3). Immediate effervescence takes place, and the bent tube is passed into

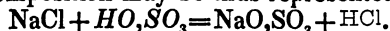
Fig. 15.



a dry bottle of about a pint capacity, which should be furnished with a greased stopper; while the bottle is filling, the mouth may be loosely closed with a piece of card or paper.

Observe the dense fumes which are formed wherever the gas mixes with the air, especially if the atmosphere is damp, owing to the combination of the gas with the aqueous vapor. The bottle may be considered full when the gas has been flowing over from the mouth of the bottle for two or three minutes; the tube should then be cautiously withdrawn, and the bottle tightly closed with the stopper. Three or four bottles may be similarly filled with the gas, a gentle heat being applied if necessary.

The decomposition may be thus represented:—



the sulphate of soda of course remains in the retort.

51. Ascertain the action of the gas on a lighted taper.

52. Remove the stopper from one of the bottles, instantly close it again with a dry glass plate, and plunge it with the mouth downwards into the water of the pneumatic trough. If the bottle has been well filled, the water will, when the glass plate is removed, quickly rise and nearly fill it, while the unabsorbed residue shows the quantity of common air left in the bottle.*

* Water at common temperatures is capable of dissolving no less than 480 times its own volume of hydrochloric acid. The liquid hydrochloric or muriatic acid of commerce, is a solution of the gas in water.

This experiment must not be made without first removing the stopper, and substituting the glass plate; if it is attempted to take out the stopper while the bottle is under water, there is great danger of its becoming so firmly fixed, as to be almost incapable of removal, owing to the absorption of the gas by the water, and the formation of a partial vacuum.

53. Test a little of the acid solution obtained in the last experiment, in a tube with litmus paper, and afterwards with a few drops of solution of nitrate of silver (AgO, NO_3). The white precipitate, which is chloride of silver ($AgCl$), will be found to be insoluble in nitric acid, but readily soluble in ammonia (429).

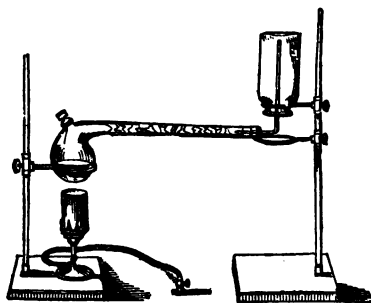
54. Reserve a bottle of the gas for an experiment (60) with ammonia.

SECTION VIII.

*Preparation of Ammoniacal Gas (NH_3).**

55. This gas may be prepared in a similar manner to the last, but as it is specifically lighter than common air, the

Fig. 16.



bottles in which it is collected must be kept while filling, with the mouth downwards, the delivering tube passing

* The specific gravity of ammoniacal gas is 0.589, 100 cubic inches weighing 18.288 grains. Its atomic weight is 17, and its atomic volume 2.

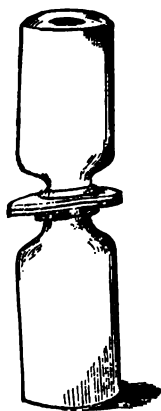
upwards to the top; the neck of the retort should be furnished as before with a roll of filtering paper.

56. Reduce 300 grains of quicklime (CaO) to powder in a mortar, and slake it in a small basin with a drachm and a half of water; then pound 400 grains of muriate of ammonia (NH_4Cl); mix the powders as quickly as possible, and without loss of time transfer the mixture to the retort. If the gas does not come over rapidly, a gentle heat may be applied. When three or four bottles have been filled, proceed with the following experiments:—

57. Observe the effect of the gas on a lighted taper: it extinguishes the flame, and at the same time shows a slight tendency to burn with a pale green flame.

58. Remove the stopper from one of the bottles and close the mouth with a dry glass plate; then invert it, and having placed it under water, remove the glass plate and observe the rapid absorption. That which remains unabsorbed is atmospheric air.*

Fig. 17.



59. Test the liquid obtained in the last experiment (which is a weak solution of ammonia), with turmeric and reddened litmus paper; the first is turned brown, the latter has the blue color restored.

60. Remove the stopper from a bottle of the gas, and also from the reserved bottle of hydrochloric acid (54), replacing them with dry glass plates. Then invert the latter over the bottle of ammonia, and cautiously remove the glass plates so as to allow the gases to mix. Dense white fumes, consisting of muriate of ammonia (NH_4Cl), are immediately produced, which in a short time collect in flakes, and fall like snow on the sides and bottom of the vessels. In this combination of the hy-

drochloric acid with the ammonia, considerable heat is evolved.

* Water at common temperatures is capable of absorbing nearly 700 times its volume of ammoniacal gas.

CHAPTER II.

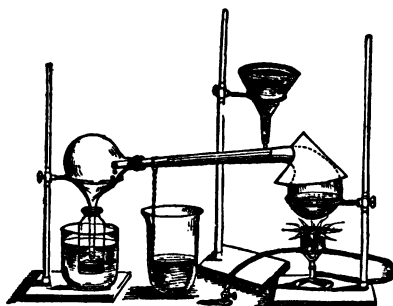
DISTILLATION.

SECTION I.

Distillation of Water.

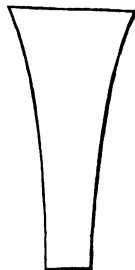
61. ADAPT a cork to the neck of a quilled receiver, and bore a hole through it to fit the neck of the retort, which should pass through it for about two inches. When this

Fig. 18.



is done, the apparatus may be fitted up as shown in the figure. The funnel which supplies water for cooling the neck of the retort, has its throat partially obstructed by a plug of tow, to regulate the flow of liquid; the neck of the retort is covered by a slip of bibulous paper of the form of the annexed sketch, cut of such a width as almost completely to encircle the neck; and between the lower end of the paper and the quill receiver, a thin fillet of tow is twisted tightly round the glass, to carry off the superfluous water, which drops into a basin placed underneath for its reception. The quill of the receiver passes into a small

Fig. 19.

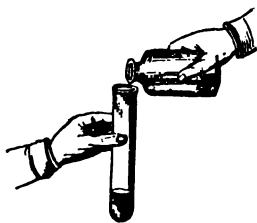


flask or bottle, which is kept immersed in water during the process, in order to keep it cool.

62. When the apparatus is thus arranged, the retort must be cautiously charged with common water till nearly half full, care being taken that none of it gets into the neck, as it would run down into the receiver, and contaminate the distilled water, which should otherwise be pure. The upper part of the body of the retort being then covered with a conical cap of paper to prevent loss of heat by currents of air and radiation, the lamp may be applied, care being taken that the ebullition does not go on too violently, lest any of the impure water should splash or boil over into the neck of the retort. If, instead of boiling quietly and uniformly, the water in the retort "bumps," owing to the sudden disengagement of large bubbles of steam, a few fragments of broken glass or platinum wire may be placed in the retort, to assist the formation of small bubbles from their surface. The first ounce of water that comes over, should be rejected as impure, after which two or three ounces may be distilled for examination.

63. While the distillation is going on, another portion of the water operated on may be tested, with the view of discovering some of the impurities present in it. Fill four test-tubes about one-third full of the undistilled water, and add to them respectively a few drops of the following reagents.

Fig. 20.



(a.) To the first add a solution of *chloride of barium* ($BaCl$); a white precipitate, insoluble in nitric acid,* indicates the presence of sulphates (403), most commonly sulphate of lime (CaO , SO_3).

(b.) To another portion add a solution of *nitrate of silver* (AgO , NO_3). If any chloride is present (usually chloride of sodium

* In testing the solubility of a precipitate in any liquid, pour off a small portion into a separate tube for the experiment, reserving the rest for comparison.

(NaCl), a white curdy precipitate of chloride of silver (AgCl) will be produced, insoluble in nitric acid, but readily soluble in ammonia (429). By exposure to the light this precipitate gradually becomes purple, especially when the water contains organic matter.

(c.) To the third tube add a little *lime-water* (CaO in water): a white precipitate, soluble in nitric acid, shows that carbonic acid (CO_2) is present (420).

(d.) To the remaining tube *oxalate of ammonia* (NH_4O , C_2O_3) may be added, which will give a white precipitate if any lime is present (218).

64. Test the distilled water in the same way; if pure it will of course furnish no precipitate with any of the reagents.

65. Evaporate a few drops both of the distilled and undistilled water on platinum foil or a clean slip of glass: a considerable residue will probably be left by the latter, but no trace of solid matter ought to be observable where the other lay.

66. During ebullition, the water in the retort usually becomes turbid, owing to the formation of a white insoluble powder, which may be separated by filtration when the distillation is over.

To prepare a filter, take a small piece of white filtering

Fig. 21.

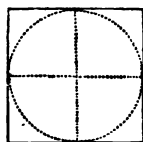
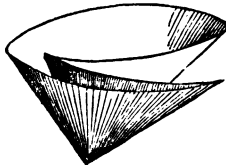


Fig. 22.

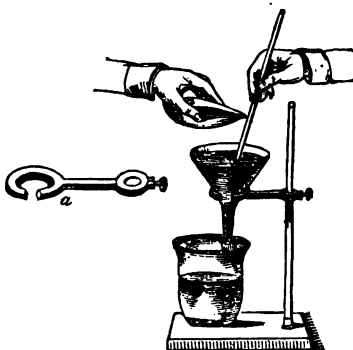


or blotting paper, and fold it twice from side to side; then round off with scissors the projecting corners, so that the paper may fall wholly within the funnel. Moisten the paper placed in a funnel with distilled water, and then carefully pour in the liquid to be filtered, using a glass rod to conduct it (636).

When most of the liquid has passed through, the white powder may be detached with a knife from the paper, and

introduced into a test tube; the clear solution being reserved for examination (68).

Fig. 23.



67. (a.) Add a few drops of dilute *nitric acid* to the powder in the tube, and observe that it dissolves with effervescence, indicating that it is a carbonate (419).

(b.) Supersaturate the solution thus obtained, with ammonia, and add a little *oxalate of ammonia* ($\text{NH}_4\text{O}, \text{C}_2\text{O}_3$): a white precipitate shows the presence of lime (218). The powder is thus proved to be carbonate of lime (CaO, CO_2).*

68. Test the solution filtered from the carbonate of lime in (66) with *chloride of barium*, *nitrate of silver*, *lime-water*, and *oxalate of ammonia*; and compare the results with those obtained in (63), when the water was examined in its natural state. As most of the lime has been separated as carbonate, we may expect to find less of it in solution than before, but more of the sulphates and chlorides, since they still remain dissolved in a more concentrated form.

* This carbonate of lime had been held in solution by the excess of carbonic acid contained in the water; when the latter is expelled during ebullition, the carbonate is precipitated.

SECTION II

Distillation of Liquid Hydrochloric Acid (HCl in water).

69. Fit up the apparatus as in the ordinary process of distilling water (61), taking care that all the joints are perfectly tight; then remove the retort, and introduce through the tubulure 1000 grains* of dry chloride of sodium (NaCl) in coarse powder, taking care that none of the particles fall into the neck of the retort: then adjust the apparatus as before. Measure into the small flask or bottle which is to receive the distilled acid, 12 fluidrachms of water, and mark with a file or a strip of waxed paper, the height at which it stands; and having emptied it, measure into it seven drachms of distilled water. During the distillation care must be taken that the quill of the receiver dips under the surface of this water, which will assist in condensing the acid fumes, some of which might otherwise escape.

Into a small evaporating basin, pour seven drachms of water, and add gradually to it six drachms of strong sulphuric acid (HO, SO_3), stirring the mixture with a glass rod. When nearly cool, this dilute acid may be poured carefully into the retort through a small funnel, avoiding any splashing or soiling of the neck. A gentle heat may then be applied, which must be regulated according to the rapidity with which the acid distils over, great care being taken that the mixture does not boil over into the neck of the retort (50).

The distillation may be continued until twelve drachms of acid have come over, which may be known by the mark previously made in the receiving flask.

70. The acid in the receiver may now be examined as to its purity. Pour a little into a test-tube, dilute it with about three times its bulk of water, and add a few drops of a solution of *chloride of barium*; if a white precipitate ap-

* In this and many of the other experiments, small quantities are mentioned to suit the convenience of my class of Chemical Manipulation, the lessons being only two hours long. When the products of the experiments are wanted for use, much larger quantities must frequently be employed.

pears which is insoluble in the acid, it shows the presence of sulphuric acid as an impurity (403).

71. Evaporate a few drops of the acid on platinum foil or a clean slip of glass: no trace of the spot where it lay ought to remain. Any solid residue shows the presence of some saline impurity, caused probably by a little of the salt employed having got into the neck of the retort, and been washed down into the receiver.

SECTION III.

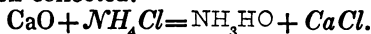
Distillation of Liquid Ammonia (NH_3 in water).

72. Prepare the apparatus as in the distillation of hydrochloric acid (69).

Pound 450 grains of quicklime (CaO), introduce it into the retort through the tubulure, and pour gradually upon it two ounces of distilled water. Measure into the receiving flask or bottle fifteen drachms of water, and mark with a file or waxed paper the height at which it stands; empty it and pour in two drachms of distilled water for the quill of the receiver to dip into during the distillation.

Weigh out 530 grains of muriate of ammonia (NH_4Cl), dissolve it in three ounces of water in a small evaporating basin, and pour the solution into the retort.

The distillation may now be commenced, carefully regulating the heat, and continuing it until the distilled liquid reaches up to the file mark in the receiver, when 15 drachms will have been collected.



73. Pour a little of the ammoniacal solution thus prepared into a test-tube, and add to it a few drops of *chloride of barium*: if a precipitate appears, it is owing to the presence either of carbonic or sulphuric acid. To distinguish between them add *nitric acid* in slight excess; if the precipitate thereupon dissolves, it is carbonic acid (421); if not, it is sulphuric (403).

74. Test another portion of the ammoniacal solution with a little *oxalate of ammonia*; if a white precipitate is formed, it is owing to the presence of lime as an impurity (218).

75. Supersaturate a little of the distilled liquid with nitric acid in a test-tube, and add a few drops of a solution of *nitrate of silver* (AgO,NO_3); a white precipitate indicates the presence of hydrochloric acid or a chloride. If a further portion of the ammoniacal solution be added, so as to render the liquid alkaline, the precipitate redissolves (429).

76. If no precipitate occur with any of these tests, evaporate a few drops of the ammoniacal solution on a slip of glass or platinum foil, and observe whether any trace of saline impurity is left.

SECTION IV.

Distillation of Liquid Nitric Acid (NO_3 in water).

77. Fit up the apparatus as in the distillation of hydrochloric acid (69). Introduce into the retort 1000 grains of nitrate of potash (KO,NO_3); pour upon it ten drachms of strong sulphuric acid (HO,SO_3), and apply a gentle heat, observing the same precautions as were recommended in the former cases (61, 69).



78. While the distillation is going on, dissolve a few crystals of the nitrate of potash in distilled water, for the purpose of ascertaining its purity.

(a.) Test a little of the solution with *nitrate of silver* (AgO,NO_3); if any chloride is present, a white curdy precipitate appears, which is insoluble in nitric acid, but readily soluble in ammonia (429).

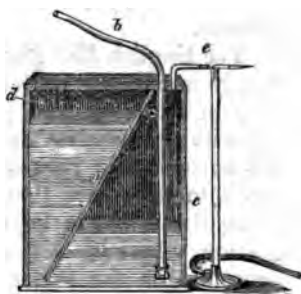
If the nitrate employed is contaminated with any chloride, the acid that distils over is sure to contain a little hydrochloric acid (HCl).

(b.) To another portion, add a solution of *chloride of barium* ($BaCl$); if any sulphates are present, a white precipitate is produced, which is insoluble in nitric acid (403).

79. Dissolve a small quantity of the nitrate of potash in hot water, in an evaporating basin, adding the salt as long as it is taken up by the water on stirring; pour the hot solution into another basin, and observe the gradual formation of crystals as it cools. Remove some of these from

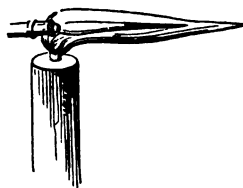
by the plate *a*, which passes down to within about half an inch of the bottom, thus leaving a communication open between the two. The lower end of the tube *b* is closed by a valve opening outwards, to prevent the escape of air in that direction : the box should be filled about half full of water, and when used, air is blown through the tube *b*. The pressure thus occasioned in the compartment *c*, forces a portion of the water into the next division *d*, where it rises to a higher level than in *c*, and by its superior pressure forces a stream of air through the fine aperture at the extremity of the tube *e* as long as it continues to stand at a higher level than in *c*. In this way a continuous jet is readily obtained, with much less fatigue to the operator than with the mouth blow-pipe.

Fig. 25.



83. If the blowpipe flame be examined, it will be found to consist of two distinct parts, which may be called for the sake of distinction, the inner and the outer flame. The blue point of the inner flame is evidently surrounded on all sides by the burning gas, no atmospheric oxygen being near it, so that any substance containing oxygen loosely combined, placed in it, will be decomposed by the powerful deoxidizing affinities of the carbon and hydrogen of the combustible gases : on this account the inner flame is usually called the *deoxidizing* or *reducing* flame. The outer flame, on the contrary, is surrounded on all sides by the external air, so that here there is no excess of combustible or deoxidizing matter, but rather an excess of atmospheric oxygen ; so that an oxidized substance may be placed at its extremity without danger of oxidation, unless such decomposition is effected by the

Fig. 26.

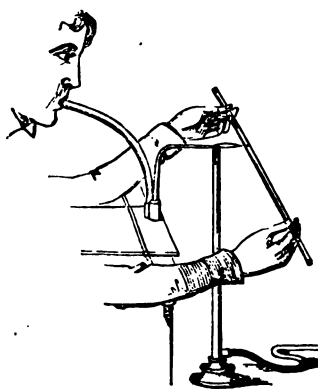


mere heat of the flame, independent of its chemical action; on the other hand, most substances, having an affinity for oxygen, placed without its influence, become oxidized at high temperatures, and hence it is usually called the *oxidizing flame*.

84. The English flint glass, of which the tubes and rods commonly in use are made, contains in its composition a quantity of oxide of lead (PbO), which, when heated in contact with deoxidizing matter, is very easily decomposed. On this account it is necessary, in heating glass with the blowpipe, to take care that it does not approach the deoxidizing flame, but is kept at the extremity of the oxidizing flame, otherwise a black stain of metallic lead will be deposited on the surface of the glass. Slight stains of this description may generally be removed by holding the glass for a few seconds in the oxidizing flame; this converts the lead again into oxide, which dissolves in the glass.

85. *Make a few glass stirring rods, of lengths varying from five to eight inches.* To do this, a piece of solid rod,

Fig. 27.



long enough to make two stirrers, should be held at a short distance from the extremity of the flame, and gradually brought towards it, a rotating motion being communicated to it by means of the finger and thumb, so that the part where the heat is applied may be uniformly heated all round. When the glass begins to soften, it should be gently pulled with both hands, until it assumes the form represented in the figure, when it may be removed from the flame, and

having been scratched with a file across its narrowest part is gently broken asunder. The sharp edges are then held in the flame until they are round and uniform; after

Fig. 28.



Fig. 29.



Fig. 30.



which the other end may be worked in the same way, only making it rather more tapering and pointed.

86. *Join together two rods of equal diameter.* For this purpose, take two short pieces of rod, the extremities of which are smooth and flat, and hold the ends which are to be united in the blowpipe flame until partial fusion takes place. Then with a steady hand bring them together, observing that the edges of both coincide, and press them gently, so as to cause them to cohere perfectly together. Keep the newly-formed joint in the flame for some minutes, turning it constantly round, and alternately pulling and pushing, in order to weld the two pieces firmly together. When this is properly done, the rod is as strong at the junction as in any other part, but a slight inequality will always be visible, however neatly the operation may have been performed.

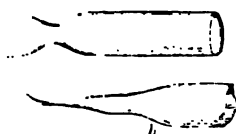
Fig. 31.



87. *Make a specific gravity glass* of the form and size shown in the figure (149).

88. *Make a small syphon tube.* Take a piece of tubing ten or twelve inches long, and a fourth or a third of an inch in diameter, and hold it diagonally in the flame of a gas or spirit-lamp, turning it constantly round, and by gently moving it up and down in the flame, heating two or three inches of the central part of the tube. When the glass begins to soften, apply a gentle pressure with both hands, so as to bend it slowly, and continue to do so until it has assumed the form shown in the figure. If the tube is too strongly heated, or if the pressure be too strongly and suddenly applied, the bend, instead of being

... may be air
... it is very
... slowly, or v
... of temp
... the tube must
... heated to red
... flame of the bl
... erated on is at al
... term, some care is
... or gradually cool
... by removing it
... then laying it at
... the hot part on
... stance, and cover
... id cooling by radi
... ce of tube may be
... ch in diameter, and
... ve for two test-tubes



... be heated in the manner
... (85), and gradually dr
... turned round, when it
... figure. The heat sh
... the tube marked *a*, and
... at, care being taken n
... that is formed, and v
... tube, until the base o
... uniform; when this i
... ad has become very
... the point where it join
... and separate, leavin
... There will general
... however, a small
... by a portion of the t
... this, again heat the
... and the lump disapp

having been
part is gently
held in the flau

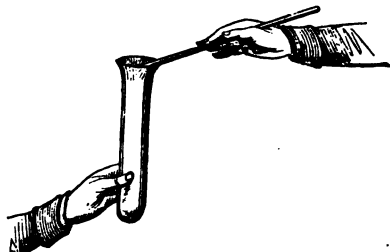
On removing the tube from the flame, blow air gently into it, for the purpose of swelling out the bottom to its previous round form, as it usually collapse and flattens while in a state of fusion. Fig. 34.



90. The other portion of the tube may now be finished in a similar way, by applying heat to the point *b* and drawing off the irregular termination until the thread of glass is sufficiently attenuated to be removed.

When it is required to make a test-tube of a piece of tubing only long enough for one, all that is necessary is to melt on to one end another piece of waste tubing or rod, to serve as a handle, after which the end may be drawn off as in the former case.

91. To complete the tube, the open end must be spread out a little, as shown in the figure, so as to form a kind of border. This is done by softening the end in the blowpipe flame, and then by means of a thick iron wire, or the smooth end of a file (which should be previously heated by being held in the flame) introduced and carried round the opening, the edge is uniformly pressed outwards. Fig. 35.



92. *Cement together two tubes of equal diameter.* This is done in a similar manner to that already described in the case of rods (86). It requires, however, more care and dexterity to maintain the tube of nearly uniform thickness at the point of junction, as it is liable to collapse and become irregular in form. When it does so, one end of the tube should be stopped up with a bit of cork or by hermetically sealing, and while the junction is in a state of semi-fusion, air should be gently blown into the tube: in this way it may be brought again into a proper form. When the glass is thin, Fig. 36.



the edges which are to be united may be spread out a little, as shown in figure, by means of a heated wire or file (91), when the joint will be stronger than it would otherwise be.

93. *Cement together two tubes of unequal diameter.* When it is required to join a narrow tube to a wider one, it is necessary to draw out the latter in the blowpipe flame until a portion of it is contracted to the diameter of the former (85); then with a file it is divided at that point of equal diameter, and cemented to the smaller tube in the

Fig. 37.

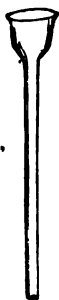


Fig. 38.



same way as in the previous case. Sometimes, when the glass is thin, it is advisable to widen the extremity of the smaller tube, so as to overlap the other, which is readily done by means of an iron wire (91).

In this operation, it is always advisable to maintain the junction in the flame for some little time, to allow of the complete amalgamation of the two portions of glass; and as the tendency to collapse is greater the longer it is fused, it will generally be found necessary to blow it out slightly as recommended in (92).

In this way, some small funnels may be made.

Fig. 39.



94. *Prepare tubes for a washing bottle.* The tubes required for this purpose are of the form shown in the figure, the upper end of the longer one being drawn out so as to leave only a small aperture.

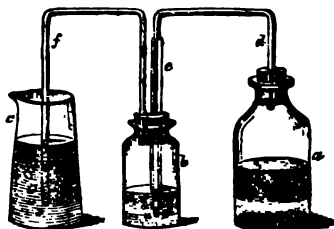
When the bottle is prepared and filled with water, a small stream of water may be forced through this tube by blowing air down the shorter one; it is of great service in washing precipitates on a filter, and for many other purposes (169).

95. *Prepare tubes for a sulphuretted hydrogen (hydrosulphuric acid) apparatus.* The form of apparatus used for generating hydrosulphuric

acid, and passing it into water or saline solutions, is represented in the figure (728).

The finer tubes, *d* and *f*, may usually be bent in the naked flame (88), the extremities being afterwards slightly fused with the blowpipe in order to round off the sharp edges; and care must be taken that the wider tube *e* is of sufficient calibre to admit of the tube *d* passing freely down it.

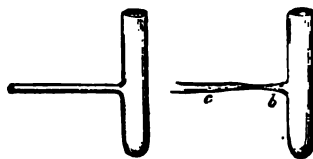
Fig. 40.



96. *Attach a narrow tube at right angles to a wider one.*

Heat the wider tube to redness at the point where the junction is to be made; and by means of a bit of waste rod or tubing *c*, draw it out, when it will assume the form represented in the figure; then with a sharp file remove the portion *c* at the point *b*, and fuse to the projecting piece thus left, the smaller tube, in the manner described in (93).

Fig. 41.



97. *Blow some small bulbs.* When it is required to blow a bulb at the end of a tube, the extremity should be closed as in making a test tube, (89); if the glass is tolerably thick, and the bulb to be blown not large, all that is necessary is to heat the end for about half an inch as strongly as possible; and then, having removed it from the flame, and holding it horizontally in the hands, to blow air into it until the pressure forces the softened glass to expand, which it will do in the form of a round bulb if the heat has been properly applied, and the tube be kept constantly turned round while in the hands. This

Fig. 42.



latter precaution is absolutely necessary, as the soft glass would otherwise bend with its own weight in one direction, thus destroying the proper form of the tube.

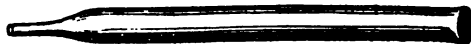
98. *Seal a few tubes hermetically at both ends.* This is an operation of very frequent use in the laboratory, as it furnishes the most convenient and efficient means of preserving small specimens of many rare substances, especially such as are volatile.

The tube is first sealed at one end, precisely as Fig. 43. if it were intended for a test tube (89): the liquid or other substance for which it is designed, is then introduced as soon as the tube is quite cold, care being taken that the upper part of the tube is not wetted or soiled. The flame of the blowpipe is now directed to the portion of the tube a little above that intended for the sealed end, and when sufficiently soft, it is drawn out to a capillary tube, and allowed to cool: it may afterwards be sealed by fusing the lower part of the capillary tube *a*, by momentary contact with the flame.

In this way seal a little sulphur in a tube without melting or volatilizing any of it, the sulphur being within an inch and a half of the upper end.

99. *Seal some water hermetically in a tube.* Having sealed the tube at one end, while it is cooling, take another piece of tubing, which may be eight or nine inches long, and a quarter of an inch in diameter, and draw it out in the blowpipe flame; then divide it in the thin part by means of a

Fig. 44.



file, when it will have the form shown in the figure; and when the sharp edges have been rounded off in the blowpipe flame, may be used as a pipette for introducing a little water into the sealed tube without wetting its sides.

Then draw out the capillary neck (98), and when cold, seal it as before, leaving not more than the space of an inch between the upper end and the surface of the water.

CHAPTER IV.

EXPERIMENTS WITH THE MOUTH BLOWPIPE.

100. BEFORE proceeding to any blowpipe experiments, it is necessary to acquire the knack of keeping up a constant and unintermitting blast of air from the mouth, as without this, it is impossible to raise the heat to a sufficient degree of intensity. The habit is readily acquired, and when once attained, the mouth and lungs do their work almost mechanically, without any sustained effort on the part of the operator.

101. The learner may first observe that on closing the lips, he can still, without any difficulty, breathe through the nostrils: let him now distend the cheeks with air from the lungs, and he will find that on closing the communication between the mouth and throat he can breathe through the nostrils for a length of time, still keeping the cheeks distended. He may next introduce the mouth-piece of the blowpipe between his lips, and having puffed out his cheeks with air from the lungs, and again closed the communication between the mouth and throat, let him breathe freely through the nostrils, at the same time allowing the distended cheeks to force a current of air through the blowpipe. When the stock of air in the mouth is nearly exhausted, a fresh supply is sent up from the lungs, when the cheeks, again distended, will by their elasticity keep up a current of air through the blowpipe, while the operator breathes through the nostrils as before.

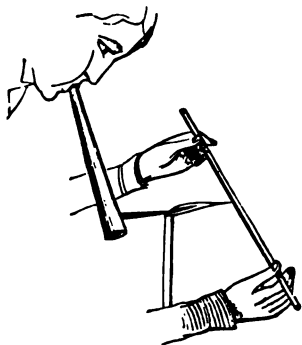
The cheeks thus play the part of an elastic bag, with a valve opening inwards, which, if connected with the blowpipe, and distended with air, would force air through it as long as the tension of its stretched sides exerted sufficient pressure.

102. Seal a few tubes for the following experiments. The tubing employed for this purpose should be about a quarter of an inch in diameter, and it may be cut into pieces about five inches long, each of which will serve for two tubes. The sealing should be effected in the manner

already described (89), and the same care relative to the deoxidizing flame is necessary, as when the water blow-pipe is used (84).

103. Heat a small fragment of wood or paper in a tube,

Fig. 45.



and observe that it blackens like all organic substances.* This blackening or charring is owing to the decomposition of the lignine, which consists of $C_{12}H_{10}O_{10}$; when exposed to a high temperature the hydrogen and oxygen, with a portion of the carbon, pass off in the form of acetic or pyroligneous acid ($HO, C_4H_3O_3$) and tarry matter, with other volatile compounds, leaving behind a carbonaceous residue. The acid character of the vapor may be seen by introducing

a strip of moistened litmus paper into the upper part of the tube while the decomposition is going on, when it will be speedily reddened.

104. Treat a fragment of horn ($C_{48}H_{30}N_7O_{17}$) or isinglass ($C_{90}H_{82}N_{13}O_{30}$) similarly in another tube:† observe the character of the carbonaceous residue, and introduce a bit of yellow turmeric paper, which will be turned brown, showing that the vapor is alkaline; this is owing to the presence of ammonia (NH_3), which is almost invariably produced when an organic compound containing nitrogen is decomposed by heat. The odor of the fumes should also be noticed, and contrasted with those formed in the last experiment.

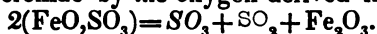
105. Heat a little gypsum or sulphate of lime ($CaO, SO_3 + 2Aq$) in a tube, and note whether it undergoes any change. It parts with the two equivalents of water of crystallization, which condense in the upper part of the tube.

* In this and most of the following experiments, especially when the substance operated on is of a deleterious or poisonous nature, the quantity used should not exceed a pin's head in size.

† When a tube is at all soiled in an experiment, it is unfit for further use.

106. Treat a crystal of sulphate of iron ($\text{FeO}, \text{SO}_3 + 6\text{Aq}$) in a similar manner, observing the successive changes which are produced, and examine the liquid which condenses in the upper part of the tube, with litmus paper.

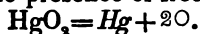
When first heated, five equivalents of water are expelled, leaving a whitish powder, which consists of the sulphate with one equivalent of water ($\text{FeO}, \text{SO}_3, \text{HO}$). On continuing the heat, the sulphuric acid is volatilized, a portion of it being decomposed by the protoxide of iron, which is converted into peroxide by the oxygen derived from the acid.



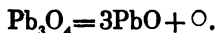
107. Repeat the experiment, using sulphate of potash (KO, SO_3) instead of sulphate of iron: the decrepitation is owing to the escape of a little water, which is mechanically lodged between the plates of the crystals. The salt undergoes no further change.

108. Sublime a little calomel (HgCl), and corrosive sublimate (HgCl_2), in two separate tubes, and note the different appearances which are presented in both cases.

109. Heat a little red oxide of mercury (HgO_2) in a tube; observe the rapid change which it undergoes, and the minute globules of metallic mercury which condense in the upper part of the tube. If a glowing match be introduced while the decomposition is going on,* it will indicate by its vivid combustion, the presence of free oxygen.



110. Repeat the experiment with some red oxide of lead (Pb_3O_4), and observe in what respects the results differ from the last. The yellowish residue which is left is protoxide of lead or litharge (PbO), one-fourth of the oxygen being expelled.

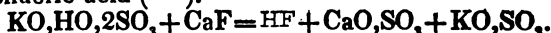


111. Heat a little arsenious acid (AsO_3) in a tube, and observe closely the characters of the crystalline sublimate (302).

112. Mix together equal portions of nitre (KO, NO_2) and bisulphate of potash ($\text{KO}, \text{HO}, 2\text{SO}_3$), and heat the mixture in a tube; test the nitrous vapor which is given off, with litmus paper, and endeavor to account for its formation.

* The open end of the tube may be loosely closed by the finger, to retard the escape of the disengaged oxygen.

113. Heat a mixture of pounded fluor spar (CaF) and bisulphate of potash ($\text{KO}, \text{HO}, 2\text{SO}_3$) in a glass tube. The corrosive action on the glass is owing to the formation of hydrofluoric acid (HF).



114. Mix a little iodide of lead (PbI) with bisulphate of potash, and heat the mixture in a tube: the beautiful violet colored vapor which rises and condenses in the upper part of the tube is iodine.



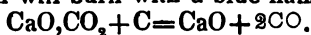
115. Fuse a little phosphate of lead ($3\text{PbO}, \text{PO}_3$) on charcoal, and observe the semi-transparent crystalline appearance of the bead on cooling (412).*

116. Heat a little oxide of zinc (ZnO) on charcoal; observe that it assumes a yellow color when heated, but becomes white again on cooling.

117. Notice the change of color that ensues when chromate of lead (PbO, CrO_3) is gently heated, and observe whether the yellow color returns on cooling.

118. Repeat the experiment with red oxide of mercury (HgO_2), taking care that the heat is not raised so high as to cause decomposition (109).

119. Mix together a little chalk (CaO, CO_2) and charcoal, and ignite the mixture in a tube: carbonic oxide gas is given off, which will burn with a blue flame.

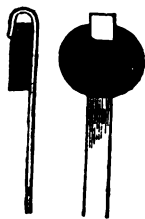


120. Heat a small crystal of carbonate or any other salt of soda on platinum wire (which should be fused into a

Fig. 46.



Fig. 47.



glass handle, and bent at the end as shown in the figure), and observe the intense yellow color it communicates to the blowpipe flame.

* When charcoal is used as a support in blowpipe experiments, it should be cut into slices about the third of an inch in thickness, having a small cavity scooped out with the point of a knife, in which to lodge the substance to be heated. The charcoal may be conveniently held during the experiment in a loop of tin plate, in the manner shown in the figure.

Then wash the wire, and compare its action on the flame with that caused by the soda.

121. Repeat the experiment, using nitrate of strontia (SrO, NO_3) instead of the soda: the color of the flame will become crimson.

122. Heat a little chalk or marble (CaO, CO_2) on charcoal, and note the dazzling white light which is produced, showing that the illuminating power of flame is not dependent only on the degree of heat, but on the presence of some solid matter in the flame;* since the blowpipe flame, which heats it, and which is of course at least as hot as the lime, emits scarcely any perceptible light.

During the ignition, the carbonate of lime is decomposed, and caustic lime (CaO) is left, the alkaline nature of which may be shown by placing a fragment of it, after ignition, on moistened turmeric paper, which will become brown at the point of contact.

123. A piece of alumina (Al_2O_3) or alum ($\text{Al}_2\text{O}_3, 3\text{SO}_3 + \text{KO}, \text{SO}_3 + 24\text{Aq}$) ignited in the flame, radiates a faint bluish light.

124. Dip a glass rod in a solution of nitrate of cobalt (CoO, NO_3), and moisten a small crystal of alum with it; then ignite it on charcoal for a few minutes, and observe the beautiful blue color which it assumes. This is a highly characteristic test for alumina.

125. Repeat the experiment, with sulphate of magnesia ($\text{MgO}, \text{SO}_3 + 7\text{Aq}$), which, when ignited with nitrate of cobalt, gradually assumes a pale rose color.

126. A salt of zinc, as the sulphate ($\text{ZnO}, \text{SO}_3 + 7\text{Aq}$), when similarly treated, becomes green.

It is easy, therefore, to distinguish between alumina, magnesia, and zinc, in this simple manner.

127. Heat a fragment of tin in the deoxidizing flame until it fuses into a bright metallic globule: when white hot, throw it on the table, when it will divide into numerous small globules, which run rapidly about, burning with a white light, and leaving behind them white trains of oxide (SnO_2).

128. Heat another fragment of tin, and keep it fused and

* See Daniell's Chemical Philosophy, p. 361.

bright in the deoxidizing flame for two or three minutes; then oxidize it in the outer flame, and again reduce it to the metallic state.

129. Heat a little acetate of lead ($\text{PbO}, \text{C}_4\text{H}_3\text{O}_3 + 3\text{Aq}$) on charcoal: observe first the liberation of acetic acid ($\text{H}_2\text{O}, \text{C}_2\text{H}_4, \text{CO}_2$) and the deposition of a portion of the carbon; and on a further application of heat, the oxide of lead first deposited is reduced to the metallic state, especially when it is kept in the deoxidizing flame. The yellow ring which surrounds the metallic bead is protoxide of lead (PbO).

130. Reduce oxide of bismuth (Bi_2O_3) in the same way: compare the beads of the different metals thus obtained, as to outward appearance, crystalline structure, malleability, &c.

131. Heat a small crystal of sulphate of copper ($\text{CuO}, \text{SO}_3 + 5\text{Aq}$) in the reducing flame on charcoal, and observe the successive changes which it undergoes; first into black oxide (CuO), and ultimately into a bead of metallic copper. Hammer out the globule, so as to render visible its peculiar color.

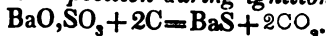
132. Mix together a little sulphate of baryta (BaO, SO_3) and charcoal in a mortar, and fold a small quantity of the mixture under one corner of a slip of platinum foil. Heat it strongly in the blowpipe flame, and when the ignited mixture is cool again, put it into a small tube, and treat it with a drop or two of dilute

Fig. 48.

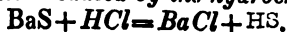


hydrochloric acid (HCl). Observe the effervescence caused by the escape of hydrosulphuric acid gas (HS), which may be recognized by its peculiar odor, and by a piece of paper moistened with a solution of acetate of lead, which is instantly blackened by it (438). In this experiment the sulphate of baryta is deoxidized by the charcoal, becoming sulphide of barium (BaS), which, when acted on by hydrochloric acid, is decomposed, and hydrosulphuric acid liberated.

Decomposition during ignition.



Decomposition caused by the hydrochloric acid.



133. Sublime a little sulphur in a small tube open at both ends: while in the state of vapor in contact with the atmospheric oxygen, it becomes converted into sulphurous acid (SO_2), the presence of which may be shown by its property of reddening litmus-paper when moistened, and bleaching it when dry: its smell also is well known and characteristic.

134. Heat a small quantity of sulphide of antimony (SbS_3) in an open tube: observe the formation of oxide of antimony (Sb_2O_3) which appears as white fumes, and test for the presence of sulphurous acid (SO_2) as in the last experiment. Here the oxygen of the air has oxidized both the sulphur and the metal.

Fig. 49.



135. Scoop out a cavity in a piece of charcoal *a*, and nearly fill it with a paste made of phosphate of lime ($8\text{CaO}, 3\text{PO}_5$) and water, *b*: dry it on the sand-bath, and when quite dry, place a fragment of lead upon it. Expose it to the oxidizing flame, and observe that the oxide of lead (PbO) as it is formed, is absorbed by the porous phosphate of lime, while any silver which may be present is left unoxidized, as a small metallic bead. This process is called *cupellation*.

Fig. 50.

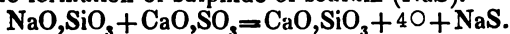


136. Fuse a little carbonate of soda (NaO, CO_2) on charcoal, and observe that it is absorbed, owing to the capillary attraction of the porous charcoal.

Fig. 51.

137. Make a bead of glass, by fusing a mixture of carbonate of soda and silica (SiO_3) (427).

138. Add a little sulphate of lime to the bead formed in the last experiment: heat it strongly in the deoxidizing flame, and remark the yellow color which it assumes, owing to the formation of sulphide of sodium (NaS).



139. Mix a little black oxide of manganese



water. Then by dividing the weight in air by the loss, or the weight of an equal bulk of water, the specific gravity is ascertained.

$$\frac{\text{Weight in air}}{\text{Loss}} = \text{Specific gravity.}$$

In this way determine the specific gravity of some of the following substances :—marble, amber, iron-pyrites, sulphate of baryta, jet, lead, zinc, glass, and agate.*

SECTION II.

Specific gravity of solids lighter than water.

146. If the solid be lighter than water, as cork, a slight modification of the above process is necessary.

Weigh the substance first in air : then select a piece of lead of sufficient size to sink the light body in water when attached to it, and weigh it (the lead) in water, suspending it by means of a hair loop, as before. If now the light substance be enclosed in the same loop with the lead, and immersed in water, it will be found that they will together weigh less than the lead did alone, owing to the buoyancy of the lighter body ; and this difference, when added to the weight of the body in air, is equal to the weight of a corresponding bulk of water.



The results may be thus recorded :—

Weight of body in air	=	_____
Weight of lead alone in water	=	_____
Weight of lead with body attached, in water	=	_____
Difference	=	_____
Add weight of body in air	=	_____
Weight of an equal bulk of water	=	=====

Having thus obtained the weight of the body in air, and

* The following are the specific gravities of these substances, some of which, however, vary considerably. Marble 2.70 ; amber 1.08 ; iron pyrites 4.90 ; sulphate of baryta 4.47 ; jet 1.30 ; lead 11.35 ; zinc 7.00 ; flint glass 3.30 ; and agate 2.60.

the weight of an equal bulk of water, the specific gravity is calculated as before.

$$\frac{\text{Weight in air}}{\text{Weight of equal bulk of water}} = \text{Specific gravity.}$$

In this way ascertain the specific gravity of wood, cork, and charcoal.*

SECTION III.

Specific gravity of insoluble powders.

147. When the substance, whose specific gravity we wish to determine, is in the form of powder, or even small lumps, it is clear that some other method must be adopted than those just described. The following is the most simple, and, for common purposes, sufficiently accurate. Counterpoise† a small bottle furnished with a stopper; then fill it completely with distilled water, close it with the stopper, taking care that no bubbles of air are left in, and weigh to determine the quantity of water it contains.‡ Having done this, empty the bottle, and dry the inside either with a cloth, or with fragments of filtering paper.

It must now be filled about two-thirds full of the powder to be examined, again weighed, and the bottle then filled cautiously with water, care being taken that all air bubbles are expelled, and that none of the powder is washed out. Again weigh.

From the data thus obtained, the specific gravity may be calculated as follows:—

Weight of the powder and water . . .	=	
Weight of the powder alone . . .	=	
Difference = weight of water left in the bottle		
Weight of bottle full of water . . .	=	
Water left in the bottle after } the powder was added	=	

* The specific gravity of these substances varies considerably, according to the degree of porosity: the following may be considered as the usual average: wood (beach) 0.85; cork 0.24; and charcoal 0.2 to 0.5.

† This is done by putting shot or strips of lead in a pill box, which, when placed in the opposite scale, are adjusted until their weight is equal to that of the bottle.

‡ Bottles may be purchased which are made to contain exactly 1000 grains of distilled water.

Weight of water displaced by, and }
 equal in bulk to, the powder } . . . =

Then as before:—

$$\frac{\text{Weight of the powder}}{\text{Weight of water displaced}} = \text{Specific gravity.}$$

In this way ascertain the specific gravity of sand, pounded glass, and shot.*

SECTION IV.

Specific gravity of liquids.

148. With a bottle similar to that used in the last experiment, the specific gravity of liquids may be readily determined.†

Counterpoise the bottle, and weigh it full of distilled water: then, by filling it successively with other liquids, weighing, and comparing the different weights with that of water, the volume of liquid being always the same, the specific gravity is obtained by proportion, thus:—

Weight of bottle full of water : 1.000 :: Weight of liquid : Specific gravity.

Care must be taken to clean the bottle thoroughly after each experiment, by washing it first with distilled water, and then with a little of the liquid whose density is to be ascertained.

Some of the following may be taken for practice:—Alcohol, solutions of chloride of sodium, sulphate of magnesia, alum, carbonate of soda, sulphate of lime, sulphate of soda, bicarbonate of soda, sulphate of copper, nitrate of potash, sulphate of zinc, and cream of tartar.

149. The specific gravity of liquids may also be determined by another process, which though not capable of

* The specific gravity of sand is about 2.60; flint glass 3.30; and shot 11.35.

† As the space occupied by a given weight of liquid varies with the temperature, or, in other words, as the weight of a given volume of any liquid is greater or less as the temperature is lower or higher, it is necessary to observe that the temperature of the liquid during the experiment does not vary much from 62°, which is usually taken as the standard. For the same reason the bottle should not be touched by the warm hand during the experiment, as otherwise the heat would cause the liquid to expand, and become specifically lighter: this may be avoided by interposing a linen cloth between the hand and the glass.

so much accuracy as the last, is frequently useful when a specific gravity bottle is not at hand.

Take a piece of solid glass rod, about the size of the figure, with one end drawn out and turned in the blowpipe flame. Weigh it first in air and then in water, suspending it with a hair-loop. Then, having wiped it dry between each experiment, weigh it successively in the liquids, the specific gravities of which are to be determined. The difference between the weight of the glass in air and in the liquid, representing in each case the weight of a volume of the liquid equal to that of the glass, and knowing the weight of a similar volume of water, the specific gravity may be known by simple calculation.

Fig. 55.



Fig. 56.



Thus:—

Weight of glass in air	.	.	.	
Weight of glass in liquid	.	.	.	_____
Loss	.	.	.	=====

which is the weight of an equal volume of the liquid.

Then by proportion,

$$\left. \begin{array}{l} \text{Weight of equal} \\ \text{volume of water} \end{array} \right\} : 1.000 :: \left\{ \begin{array}{l} \text{Weight of equal} \\ \text{volume of liquid} \end{array} \right\} : \left\{ \begin{array}{l} \text{Specific gravity} \\ \text{of the liquid} \end{array} \right\}$$

Determine in this way the specific gravities of some of the solutions already mentioned, and compare the results with those obtained with the specific gravity bottle.

CHAPTER VI.

HEATING SUBSTANCES IN GASES.

SECTION I.

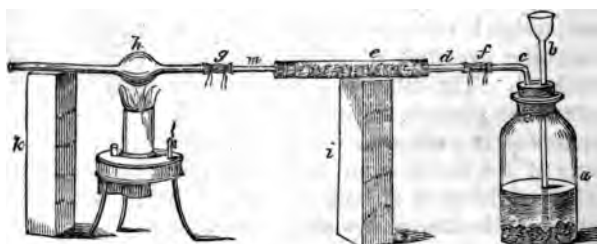
Reduction of metallic oxides by hydrogen.

150. A large number of the metallic oxides are decomposed and reduced to the metallic state when heated in an

atmosphere of dry hydrogen gas; and from the facility with which the operation may be performed, and the accurate results it gives when carefully conducted, it is frequently employed in estimating the quantity of oxygen in oxidized compounds.

151. The apparatus which is required for the purpose is shown in the figure. The bottle *a* is charged with zinc

Fig. 57.



and dilute sulphuric acid to generate the hydrogen, which is dried while passing over fragments of chloride of calcium in the tube *e*; the gas then passes into the bulb tube *h*, which contains the oxide to be reduced, the bulb being heated by the lamp placed beneath.

152. Take a piece of tubing *e* about twelve or fifteen inches long, and half an inch internal diameter, and having slightly fused the cut edges in the blowpipe flame (85), adapt a cork to each end: then, with a cork-borer or round file, perforate the corks so as to receive the small tubes *d* and *m*.* Remove one of the corks from the large tube, and push down to the other end a small loose bit of tow or cotton wool, and nearly fill it with fragments of chloride of calcium (763); put in another bit of tow (the use of which is to prevent any of the smaller fragments falling out), and again fix the cork and small tube.

Next adapt a cork to the bottle, which should have a tolerably wide neck, and bore in it two holes to fit the tubes *b* and *c*, which pass through it, the former reaching

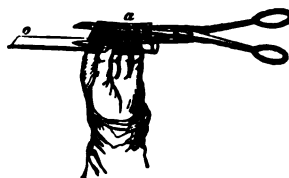
* When the tube is of such a diameter as cannot be exactly matched by any of the cork borers in the set, the holes should be bored by a smaller one, and afterwards enlarged by means of a round file, until it is of sufficient calibre to admit the tube, which must always fit perfectly tight.

nearly to the bottom of the bottle, the latter passing only just through the cork. Put 150 grains of granulated zinc into the bottle, fill it about one-third full of water, and fix the cork containing the tubes *b* and *c*.

153. In order to connect the different parts of the apparatus together, make two caoutchouc connectors *f* and *g*.

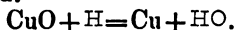
This is done by loosely folding a piece of sheet caoutchouc about an inch and a half square, round a piece of rod or tubing of the same diameter as the tubes which it is intended to join together, and cutting off with one stroke of a pair of sharp scissors the superfluous ends; when this is properly

Fig. 58.



done, the cut edges cohere, and when slightly pressed together by the thumb-nails, the junction becomes almost as strong as any other part of the tube. Care must be taken to avoid touching the newly cut edges, as the least dirt or moisture upon them would prevent them cohering properly together. It is then carefully removed from the rod, and is ready for use.

154. Having made two of these connectors, weigh the bulb tube accurately, and place in the bulb a small quantity of oxide of copper (CuO); again weigh, to ascertain the weight of oxide operated on, and connect the apparatus as shown in the figure. The caoutchouc tubes should be firmly tied round with strong twine or silk, which should be passed under and over, and tied at each half revolution to ensure perfect tightness of the joint. The apparatus being thus arranged, pour a little dilute sulphuric acid down the funnel tube *b* (12), and when the gas has been coming over about five minutes, apply a gentle heat to the bulb, and gradually increase it as long as any water is formed.



It is necessary to observe the precaution of not applying the heat immediately, since the apparatus at first contains an explosive mixture of hydrogen and common air, which would, if heat were applied, be in great danger of explod-

ing (17) and seriously injuring the operator ; by allowing five minutes to elapse, however, the whole of the common air is expelled, and the bulb may be heated without danger.

155. When the decomposition appears to be complete, no fresh water being produced,* expel by heat any moisture that may have condensed in the cool end of the tube; remove the lamp, and allow the bulb-tube to cool ; then disconnect the apparatus, and weigh the bulb containing the reduced metallic copper, the loss of weight indicating the quantity of oxygen that has been removed. Ascertain by calculation the per centage of oxygen in 100 parts of the oxide, and compare the experimental result with what is theoretically correct, the atomic weight of copper being thirty-two, that of oxygen eight, and that of the oxide forty.

SECTION II.

Heating substances in an atmosphere of carbonic acid.

156. It is sometimes required in analysis to separate two substances, one of which is volatile at a high temperature, and the other fixed, so that by merely heating the mixture, and weighing before and afterwards, the weight of each ingredient is determined. In some cases, however, it happens that the non-volatile body when heated in atmospheric air, combines with oxygen, forming a volatile compound, so that here it is necessary to conduct the operation in an atmosphere of some gas incapable of combining with it, as hydrogen or carbonic acid. For instance, in the analysis of gunpowder, which consists of a mixture of nitrate of potash (KO, NO_3), sulphur, and charcoal, the nitrate of potash is first dissolved out with water, and the insoluble residue, consisting of sulphur and charcoal, is heated in a current of hydrogen or carbonic acid, when the sulphur, being volatile, is expelled; whereas, if the mixture were to be heated in common atmospheric air, the carbon as well as the sulphur would disappear, since it would combine

* This is known by holding a piece of cold glass close to the opening at the end of the tube, and observing whether any moisture is condensed upon its surface; if not, it may be inferred that no water is coming off.

with oxygen, and become converted into carbonic acid (CO_2), which is a gas.

157. The apparatus required for this purpose is the same as that used for the reduction of metallic oxides by hydrogen (151). Fill the generating bottle *a* about one-third full of water, and put in some fragments of marble (CaO, CO_2): when the apparatus is arranged, pour in from time to time a little hydrochloric acid through the tube *b*, so as to maintain a moderate effervescence (19). Weigh the bulb tube, and put into it a little of the mixture of sulphur and charcoal; weigh a second time, to ascertain how much is used in the experiment, and connect the apparatus together. Allow the gas to come over for about five minutes, in order to displace the common air, (which might otherwise cause the volatilization of some of the charcoal, by conversion into carbonic acid,) and then heat the mixture as long as any sulphur is volatilized. As soon as the apparatus is cold, weigh the bulb-tube again, when the loss of weight will represent the quantity of sulphur contained in the mixture. The per centage of sulphur is then ascertained by calculation.

Weight of mixture : loss of weight :: 100 : per centage of sulphur.

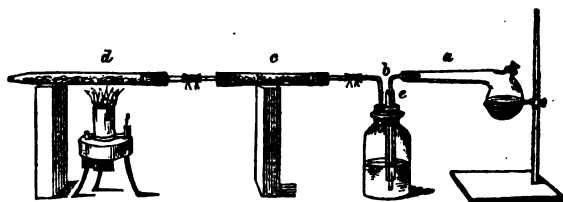
SECTION III.

Preparation of Perchloride of Iron (Fe_2Cl_6).

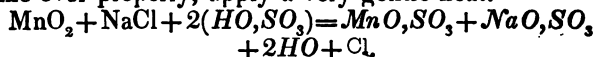
158. When metallic iron is heated in a current of chlorine gas, the two substances combine, forming perchloride of iron. The chlorine is generated in a retort *a*, to the beak of which a tube, bent at right angles *b*, should be adapted by means of a perforated cork. The retort is then charged with 700 grains of a mixture of black oxide of manganese (MnO_2) and common salt (NaCl), (in the proportion of three parts of the former to four of the latter,) on which should be poured two ounces of water. Remove the tube funnel *b* from the bottle used in the two last experiments (151), and substitute a piece of tubing *e*, sufficiently wide to admit the bent tube *b*, and reaching nearly to the bottom of the bottle, which should be filled

about a fourth part full of water. The rest of the apparatus is the same as that used in the reduction by hydrogen (151), only substituting the straight tube *d*, which may be six or eight inches long, for the bulb-tube before employed and put into it thirty grains of clean iron wire.

Fig. 59.



159. When the apparatus is connected together, slowly pour into the retort through a funnel one ounce of strong sulphuric acid (HO, SO_3), to disengage the chlorine from the mixture of manganese and salt; and if the gas does not come over properly, apply a very gentle heat.



The gas, when generated, passes through the water in the bottle *f*, which retains any hydrochloric acid with which it may be impregnated; and having passed over chloride of calcium in the tube *c*, arrives in the tube containing the iron, in a pure and dry state.

When the apparatus is filled with the chlorine, apply a gentle heat to the iron wire, and observe the beautiful scaly crystals of sesquichloride of iron (Fe_2Cl_3), which sublime and condense in the cool end of the tube. Remove a few of the crystals from the tube, and remark with what avidity they absorb moisture from the air when exposed to it for a few minutes.

Dissolve a little of the chloride in distilled water, and add ammonia (NH_3) in slight excess: the brown precipitate which is produced, is hydrated peroxide of iron (280).

CHAPTER VII.

ALKALIMETRY AND ACIDIMETRY.

SECTION I.

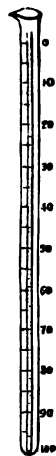
Alkalimetry.

160. THE process of alkalimetry has for its object the determination of the quantity of real alkali or alkaline carbonate in any given sample, and is founded on the principle that the quantity of alkali which is neutralized by a known quantity of acid, is always constant and uniform, in obedience to the well known laws of combination in definite proportions.

For example, forty-nine parts by weight of oil of vitriol (HO, SO_3) combine with thirty-two parts of soda (NaO), and when the two substances are brought together in these proportions, the resulting compound (sulphate of soda NaO, SO_3), is a perfectly neutral salt; but if the relative quantity of acid or alkali be greater or less than those specified, then there will be an *excess* of one of them present, and the solution containing them will be no longer neutral to test paper. Hence it appears that if we have an unknown quantity of pure alkali in a solution, we can, by treating it with an acid of known strength, and observing how much of the acid is required to neutralize it, readily determine the per centage of potash or of soda in any specimen.

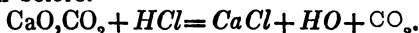
161. The apparatus employed for this purpose is a tube, capable of holding 1000 grains of distilled water, graduated into 100 parts, the divisions being numbered from the open end downwards, as in the figure. At 65 degrees there is a line scratched, marked *carbonate of potash*; at 54.6, another line marked *carbonate of soda*; at 49, *potash*; and at 23.5, *soda*; numbers, it will be observed, which bear similar relations to each other as the atomic weights of the compounds, whose names they are associated

Fig. 60.



loose plug of tow or cotton wool at each end, in the manner already described (152). Bend a piece of quill tubing in the form shown at *d* (88), and by means of perforated corks, connect the two tubes with a flat-bottomed flask, capable of holding ten or twelve ounces of water. Select a tolerably wide test tube, of such a size as will stand in the flask in an inclined position as shown in the figure, and nearly fill it with strong hydrochloric acid (*HCl*).

175. Put into the flask twenty grains of marble (CaO, CO_2) in small fragments, and pour upon it about an ounce of water: then cautiously introduce the tube *c* containing the acid, taking care that none of the acid is allowed to come in contact with the marble; connect the chloride of calcium tube with the flask, and accurately weigh the whole apparatus. Now gradually incline the flask, so as to allow the acid to flow slowly upon the marble; the carbonic acid is disengaged with effervescence, is deprived while passing over the chloride of calcium, of the moisture with which it is impregnated, and passes off through the small aperture in the tube *b*, leaving the apparatus of course lighter than before.

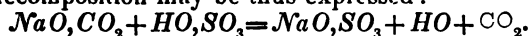


176. When the effervescence has ceased, the flask should be gently warmed, and when cool again, the cork may be removed, and air drawn through the flask by means of a small piece of tube, to abstract the whole of the carbonic acid with which it is filled, and which, being heavier than common air (22), would add to its apparent weight. The chloride of calcium tube is then replaced, and the whole apparatus again weighed; the loss of weight being of course that of the carbonic acid expelled. By multiplying this loss by 5 ($20 \times 5 = 100$), the per centage of carbonic acid in the marble is obtained.

177. Ascertain in the same way the per centage of carbonic acid in the carbonate ($\text{NaO}, \text{CO}_2 + 10\text{Aq}$) and bicarbonate of soda ($\text{NaO}, \text{HO}, 2\text{CO}_2$).

tightly with the thumb, and invert the instrument five or six times successively, in order to mix the acid and water thoroughly and uniformly together: then by cautiously relaxing the thumb, allow the acid to fall drop by drop into the alkaline solution, stirring the latter constantly with the glass rod until the litmus begins to turn feebly red. When the change of color begins to appear, wash the sides of the basin by gently agitating the liquid in it, in order to dissolve any of the splashings that may have dried during the process, and escaped the action of the acid. When the point of neutralization is nearly attained, bring one of the pieces of litmus-paper from time to time out of the solution against the heated side of the basin; if the redness disappears, more acid must be added, the reddening being thus proved to have been caused by the carbonic acid dissolved in the water; and the cautious addition of acid must be continued until a permanent feeble red color is obtained.

164. When the neutralization is complete, restore the tube to its vertical position, and remove the thumb (which until now should not have been for a moment removed), scraping it gently, so as to separate most of the adhering acid. Allow the tube to remain upright for a minute or two, in order that the sides may drain, and then observe the degree at which the acid stands, that number representing the per centage of dry carbonate in the sample.* The decomposition may be thus expressed:—



165. Determine the quantity of soda (NaO) in the same sample. This is done in the way described in the last experiment, but instead of filling the tube up to the mark *carbonate of soda* with acid, it is filled up to the mark *soda*, and then up to zero with water.†

* The atomic weight of crystallized carbonate of soda ($NaO,CO_3 + 10Aq$) being 144, and that of the dry salt (NaO,CO_3) 54, the per centage of the latter, supposing the crystallized salt to be pure, may be calculated as follows:—

144 : 54 :: 100 : x = per centage of dry carbonate of soda.

† If the crystallized salt is pure, the per centage of soda may be calculated as follows:—

Atc. wt. of crystd. carbonate of soda.	Atc. wt. of soda.	per cent. of soda.
144	32	x
:	100	:

166. Ascertain experimentally the per centage of potash (KO), and of dry carbonate of potash (KO, CO_2), in the crystallized carbonate ($\text{KO}, \text{CO}_2 + 2\text{Aq}$).*

SECTION II.

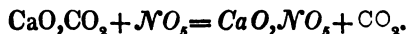
Acidimetry.

167. The process of alkalimetry being well understood, that of acidimetry will require but little explanation, as its principle is precisely analogous to that which has been described (160). In the former process the object was to determine the quantity of alkali by the quantity of acid which it was capable of neutralizing; in acidimetry, we have to ascertain the amount of real acid in any solution containing it in an uncombined form. When the acid under examination forms with lime, a salt that is soluble in water, its strength may be ascertained by determining the quantity of marble or carbonate (CaO, CO_2) which a given weight of it decomposes and dissolves. This process will serve for nitric, hydrochloric, and acetic acids.

168. Determine the per centage of nitric acid (NO_3) in a specimen of the liquid acid.

Weigh out 150 grains of pounded marble, put it into an evaporating basin, and cover it with about two ounces of distilled water. Pour a little of the acid into a glass, and thence, by means of a dropping-tube (99), transfer exactly 100 grains of it into a previously counterpoised capsule. Add this in successive portions to the marble, avoiding too large an addition at once, lest the effervescence should be so violent as to cause some of the liquid to be projected over the sides of the basin, and lost.

When the whole of the acid has been added, wash out the dish which contained it, two or three times with distilled water, and add the washings to the marble: stir the mixture repeatedly with a glass rod, and when the effervescence appears to have nearly ceased, heat it gently over a lamp.



* The atomic weight of KO is 48; that of KO, CO_2 70; and that of $\text{KO}, \text{CO}_2 + 2\text{Aq}$ 88.

169. While this is going on, fit up a washing bottle, the tubes for which have been already prepared (94). Two holes must be bored in the cork to fit the tubes, which must be fixed in the manner shown in the figure. Then prepare a filter according to the directions already given (66); and having moistened it with distilled water, support it over a beaker glass by means of a retort stand or perforated block of wood. Pour the solution from the evaporating basin down a glass rod into the filter, directing the stream, so that it may fall upon the sloping side and not into the apex, lest its force should injure or break through the paper: wash the last portions of marble out of the basin by means of the washing bottle, hold-

Fig. 62.



Fig. 63.



Fig. 64.



ing the basin in a nearly vertical position. When the liquid has for the most part passed through the filter, wash the latter with water from the washing bottle, directing the stream just below the upper edge of the filter, and continuing to wash until a drop of the filtered liquid, when

Organic Acids.

Oxalic	(HO,C ₂ O ₃)
Tartaric	(2 HO,C ₄ H ₄ O ₁₀)
Citric	(3 HO,C ₆ H ₅ O ₁₁)
Malic	(2 HO,C ₃ H ₄ O ₈)
Succinic	(HO,C ₄ H ₃ O ₇)
Benzoic	(HO,C ₇ H ₅ O ₂)
Acetic	(HO,C ₂ H ₃ O ₂)
Formic	(HO,C ₁ H ₂ O ₂)

180. Should the student find that the action of any test does not agree with that described, it may be owing to some impurity contained in the test liquid, in which case he may examine it in the manner described in the section on reagents (718).

CHAPTER II.

METALS BELONGING TO CLASS I.

Potash, Soda, Ammonia.

181. THE three bases belonging to this class are chiefly characterized by the solubility in water of most of their compounds, and the consequent difficulty of obtaining them in an insoluble form, and of separating them from one another in the shape of precipitates. They are distinguished from all other bases by producing no precipitate when tested with either of the three classifying tests, viz., hydrosulphuric acid, hydrosulphate of ammonia, and carbonate of soda, their sulphides and carbonates being all soluble in water.

Solutions of the uncombined or carbonated alkalies are alkaline to test paper, turning reddened litmus blue, and turmeric brown.

SECTION L

Potash (KO).*

A solution of chloride of potassium (*KCl*) may be used.

182. When a drop of the solution of a potash salt is evaporated on platinum foil and ignited, it leaves a fixed residue, in which respect it differs from ammonia (192).

183. Observe the action of caustic potash and carbonate of potash in solution, on *litmus* and *turmeric paper*.

Test the solution in separate test-tubes with *hydrosulphuric acid*, *hydrosulphate of ammonia*, and *carbonate of soda*. No precipitate is produced in either case.

184. It must be remembered that in many cases, precipitates do not separate *at once* from the solutions, but require *time* for their development. This is especially to be regarded in the precipitation of those salts which are to some extent soluble, as the double chloride of platinum and potassium, bitartrate of potash, ammonio-phosphate of magnesia, and many others. In all such cases, and whenever there is any doubt as to the appearance of a precipitate, it is better to leave it for a time, and not to decide that no precipitation will take place until the mixture has stood twenty-four hours. If after that period no precipitate appears, it may be safely inferred that none will afterwards be formed. It is necessary also in these cases, that the solutions should be tolerably concentrated.

185. (C) An alcoholic solution of *bichloride of platinum* ($PtCl_2$) when added to neutral or slightly acid potash solutions (especially of chloride of potassium), throws down a fine yellow crystalline precipitate, consisting of the double chloride of platinum and potassium ($KCl, PtCl_2$). If the potash solution is dilute, the precipitate does not form at once; so that it is necessary, in employing this test, when we do not obtain a precipitate immediately, to allow the mixture to stand some time (184) before we decide that no potash is present. In such cases the best way is to evaporate a mixture of the solution of chloride of potassium and chloride of platinum nearly to dryness on a water bath

* Those tests which are most characteristic are distinguished by (C).

(645), and treat the residue with alcohol, which leaves the whole of the double chloride undissolved.

As ammonia produces with chloride of platinum a similar precipitate, it is necessary before deciding that the indication is due to potash, to prove the absence of ammonia (194).

186. (C) Add a solution of *tartaric acid* ($2HO, C_4H_4O_{10}$) in excess to that of the potash salt, which should be either neutral or with a slight excess of alkali. A colorless crystalline precipitate is produced of bitartrate of potash ($KO, HO, C_4H_4O_{10}$). As in the last test, the precipitate does not appear immediately unless the solution be concentrated; so that it must be allowed to stand a short time before we satisfy ourselves that no potash is present.

The separation of the precipitate, in this and other similar cases, is much assisted by agitating the mixture with a glass rod; wherever the rod has rubbed against the sides of the tube containing it, delicate lines of microscopic crystals are deposited before any precipitate appears in the body of the liquid.

187. (C) Ignite a small fragment of a salt of potash on platinum wire in the deoxidizing flame of the blowpipe (83), and observe the violet color which it communicates to it. A small quantity of the potash (KO) is here deoxidized, and the volatile potassium (K) thus formed, is again oxidized while passing through the outer flame, which combustion is accompanied by the violet flame.

The same color may be observed in the flame of alcohol which contains a little potash in solution.

It is to be observed that in these experiments, the presence of any soda prevents the appearance of the violet tint, on account of the intense yellow color which the latter base gives to the flame.

SECTION II.

Soda (Na O).

A solution of sulphate of soda ($NaO, SO_3 + 10Aq$) may be used.

188. (C) An alcoholic solution of *bichloride of platinum* ($PtCl_2$) gives no precipitate in solutions of soda salts, even

when they are concentrated. If the mixture, however, be allowed to evaporate spontaneously, delicate yellow needle-shaped crystals of the double chloride of sodium and platinum ($\text{NaCl}, \text{PtCl}_2$) will gradually form, which are so totally different in appearance from the corresponding potash compound (185), besides being readily soluble in water and alcohol, that the two cannot be mistaken for each other.

189. (C) *Antimoniate of potash* (KO, SbO_2) when added to soda salts, either neutral or containing a slight excess of alkali, produces a white crystalline precipitate of antimoniate of soda (NaO, SbO_2) (184). If the soda salt under examination contains an excess of acid, it should be neutralized with potash before the addition of the antimoniate, as otherwise a precipitate of antimonious acid (HO, SbO_2) or biantimoniate of potash ($\text{KO}, 2\text{SbO}_2$) might be produced, owing to the decomposition of the antimoniate by the free acid.

It is necessary in employing this test, that both it and the soda solution should be tolerably concentrated, as otherwise no precipitate will be produced (184).

190. (C) When a fragment of a salt of soda is heated before the blowpipe, it communicates an intense yellow color to the flame; the same color is produced also when alcohol is mixed with a solution of soda, and burnt.

191. Neither *hydrosulphuric acid*, *hydrosulphate of ammonia*, nor an *alkaline carbonate*, produce any precipitate in solutions of soda, neither does *tartaric acid* (186).

SECTION III.

Ammonia (NH_3) or with one equivalent of water, which all its salts with oxygen acids contain (NH_4O).

A solution of muriate of ammonia (NH_4Cl) may be used.

192. (C) When heated on platinum foil, the salts of ammonia are all decomposed; and (unless the acid, like the phosphoric or boracic, is fixed at a red heat,) volatilize completely, leaving, if pure, no fixed residue. They may be in this way readily distinguished from the salts of potash and soda.

193. Like potash and soda, ammonia gives no precipitate with *hydrosulphuric acid*, *hydrosulphate of ammonia*, or an *alkaline carbonate*.

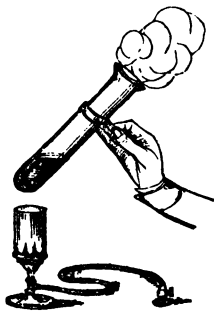
194. (C) *Bichloride of platinum* ($PtCl_2$) throws down in ammoniacal solutions, which are not very dilute, a yellow crystalline precipitate of the double chloride of platinum and ammonium ($NH_4Cl, PtCl_2$), which is very similar in appearance to that produced in solutions of potash (184, 185).

If we are doubtful whether the precipitate obtained by this test is due exclusively to ammonia, or whether it contains any potash, the precipitated double chloride may be ignited, and the residue digested in water; if the solution thus obtained give any precipitate with nitrate of silver, potash is present. The reason is this; the ammoniacal compound ($NH_4Cl, PtCl_2$) leaves, after ignition, nothing but metallic platinum; while the potash compound ($KCl, PtCl_2$) leaves a mixture of metallic platinum and chloride of potassium, the latter of which, when dissolved in water, and tested with nitrate of silver, gives a precipitate of chloride of silver ($AgCl$) (429).

195. (C) The salts of ammonia are all decomposed when gently heated in a test-tube* with a solution of *caustic potash* or *soda*, or with *hydrate of lime* (CaO, HO). The fixed alkali here combines with the acid of the ammoniacal salt, on account of its superior affinity, and sets free the ammonia.



Fig. 66.



The presence of the free ammonia in the upper part of the tube may be proved,

(a) By its well known odor;
 (b) By its alkaline reaction on turmeric and reddened litmus paper, which should be previously moistened, and then held within the tube, care being taken that it does not touch any part of it; and

(c) By the production of dense white fumes of muriate of ammonia (NH_4Cl), when a rod moistened with

* When a liquid is to be boiled in a test-tube, the latter may be conveniently held in a loop of paper or cloth, as shown in the figure.

dilute hydrochloric acid (HCl) is held near the mouth of the tube.

196. *Tartaric acid* ($2HO, C_8H_4O_{10}$) behaves with ammonia in the same way as with potash, throwing down a colorless crystalline precipitate of bitartrate of ammonia ($NH_4O, HO, C_8H_4O_{10}$), which is, however, rather more soluble than the bitartrate of potash (186).

Summary of Class I.

197. From the experiments now described, it appears that the three alkalies may be distinguished from other metallic oxides by their producing no precipitate with either hydrosulphuric acid, hydrosulphate of ammonia, or an alkaline carbonate, one or more of which causes, as we shall presently see, a precipitate with all the other bases. Hence, if we have a solution which we know to contain some inorganic saline matter, and we find no precipitate produced in it on the application of those tests, we conclude that the base of the salt is either potash, soda, or ammonia.

For the purpose of distinguishing between the three alkalies themselves, we may first test for ammonia, by heating with potash (195). If this is absent, add to a tolerably concentrated solution some bichloride of platinum or tartaric acid (185, 186), which will enable us to distinguish between potash and soda. If these tests give no precipitate, it is probable that the base is soda, which may be confirmed by the behavior of the solution with antimoniate of potash (189), and by allowing the mixture with bichloride of platinum to evaporate spontaneously, when, if yellow needle-like crystals appear, the presence of soda may be considered certain (188).

CHAPTER III.

METALS BELONGING TO CLASS II.

Magnesia, Lime, Baryta, and Strontia.

198. These bases are distinguished from the alkalies by the insolubility of many of their salts, especially their carbonates and phosphates; so that when treated with carbonate or phosphate of soda, they furnish copious precipitates.

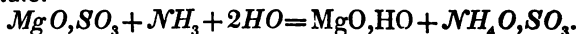
SECTION I.

Magnesia (MgO).

A solution of the sulphate ($MgO, SO_3 + 7Aq$) is the most convenient for the following experiments.

199. Neither *hydrosulphuric acid* nor *hydrosulphate of ammonia* give any precipitate in solutions of magnesia.*

200. (C) Ammonia (NH_3) when added to a neutral solution of magnesia, separates a portion of it in the form of hydrate (MgO, HO), which appears as a bulky white precipitate.



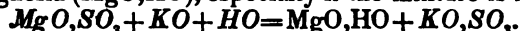
The rest of the magnesia remains in solution, in combination with the ammonia and acid, forming a soluble double salt of ammonia and magnesia ($NH_4O, MgO, 2SO_3$). Most of these double salts of ammonia and magnesia being soluble in water, and being usually formed when ammoniacal salts are present in excess, the latter have a strong tendency to interfere with the action of the reagents, which in the absence of ammonia produce a precipitate. For example, if the solution of magnesia be mixed with muriate

* When, as is sometimes the case, the hydrosulphate contains free ammonia, it may cause a slight precipitate (200).

of ammonia (NH_4Cl), and then tested with ammonia as above, no precipitate is produced.

201. Collect on a filter, and wash with distilled water, a little of the precipitated magnesia obtained in the last experiments, and place it while moist, on yellow turmeric paper; the magnesia being very slightly soluble in water, has an alkaline reaction, and turns it brown.

202. Solution of *caustic potash* (KO) precipitates hydrate of magnesia (MgO,HO), especially if the mixture is heated.



Ammoniacal salts (as muriate of ammonia), if present in the solution, prevent the formation of this precipitate, or, if added subsequently, redissolve it.

203. *Carbonate of potash* (KO,CO_2) gives a white precipitate consisting of basic carbonate of magnesia ($4MgO, 3CO_2 + 4Aq$). A portion of the magnesia remains in solution as bicarbonate, which when boiled is decomposed, and the neutral carbonate (MgO,CO_2) being insoluble, is precipitated. Ammoniacal salts, if present, prevent the formation of these precipitates, and redissolve them if subsequently added.

204. *Carbonate of ammonia* ($2NH_4O,3CO_2$) gives no precipitate unless the solution is boiled, and not even then unless it be added sparingly.

205. *Sulphuric acid* (HO,SO_3), or *sulphate of soda* (NaO,SO_3), produces no precipitate in solutions of magnesian salts, since the sulphate of magnesia is soluble in water.

206. (C) *Phosphate of soda* ($2NaO,HO,PO_5$) gives a white precipitate of phosphate of magnesia ($2MgO,HO,PO_5$) provided the solution is not very dilute, and especially on boiling.

The addition of *ammonia* or its carbonate to the magnesian solution, renders the phosphate of soda a far more delicate test than when used alone, because under those circumstances the double phosphate of ammonia and magnesia ($2MgO,NH_4O,PO_5 + 12Aq$) is produced, which is less soluble than the phosphate of magnesia, and is consequently thrown down from a more dilute solution than would furnish a precipitate with phosphate of soda alone. If the solution is very dilute, the precipitate does not appear at once, but if allowed to stand some little time,

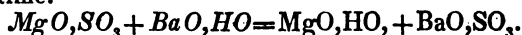
a crystalline deposit of the double phosphate gradually separates (184). Agitation of the liquid with a glass rod hastens the formation of this precipitate; and it is remarkable that if the tube be rubbed at all with the rod during agitation, lines of minute crystals are there first deposited. The same phenomenon occurs in the case of the bitartrate of potash and others, in which the precipitate is slowly deposited from a dilute solution.

As the double phosphate is readily soluble in an excess of acid, and slightly so in water, it is necessary that the solution should be pretty strongly ammoniacal.

It will be observed that in this test, the effect of ammoniacal salts in the solution is the reverse of that before described (200). When mixed with ammoniacal salts indeed, magnesia can be precipitated only by a soluble phosphate.

207. *Oxalate of ammonia* (NH_4O, C_2O_3) gives, in tolerably strong solutions, a white precipitate of oxalate of magnesia (MgO, C_2O_3), provided no other ammoniacal salts are present.

208. (C) *Baryta water* (BaO in water) gradually throws down a white precipitate of hydrate of magnesia (MgO, HO) (184). If the sulphate of magnesia be used, the insoluble sulphate of baryta (BaO, SO_3) will be thrown down at the same time.



209. (C) When magnesia or one of its salts is moistened with a solution of nitrate of cobalt (CoO, NO_3), and strongly heated before the blowpipe, the mixture assumes a pale flesh or rose-color.

SECTION II.

Lime (CaO).

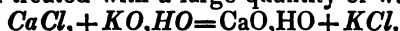
A solution of chloride of calcium ($CaCl$) or nitrate of lime ($CaO, NO_3 + 3Aq$) may be used with the liquid tests.

210. Place a small fragment of caustic lime on moistened turmeric paper; the brown color which is produced shows the alkaline nature of lime.

211. *Hydrosulphuric acid* and *hydrosulphate of ammonia* give no precipitate in solutions of salts of lime.

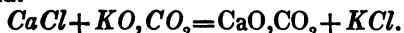
212. *Ammonia* produces no precipitate.

213. *Potash* (KO) throws down a white precipitate of hydrate of lime from concentrated solutions, which redissolves when treated with a large quantity of water.



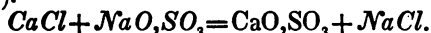
If any of the precipitate is insoluble when treated with water, it is probably owing to the potash containing a little carbonate, which would cause the formation of the insoluble carbonate of lime. If the solution of hydrate of lime be exposed to the air, it gradually absorbs carbonic acid, and a deposit of carbonate of lime takes place, which dissolves with effervescence in dilute hydrochloric acid.

214. (C) *Carbonate of potash* (KO, CO_2) throws down a copious precipitate of carbonate of lime (CaO, CO_2), which is readily soluble with effervescence in dilute hydrochloric or nitric acid.



The quantity of the precipitate increases on boiling the mixture; and its formation is unaffected by the presence of ammoniacal salts.

215. *Sulphuric acid* (HO, SO_3) or *sulphate of soda* (NaO, SO_3), when added to concentrated solutions of lime, give an immediate white precipitate of sulphate of lime ($CaO, SO_3 + 2Aq$).



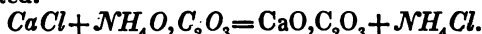
If the solution is not concentrated, the precipitate may not appear at once, but will gradually separate in the form of minute crystals (184); and if the solution is very dilute, no precipitation will take place, because the sulphate of lime, being soluble in about 500 times its weight of water, remains dissolved if sufficient water is present.

216. (C) After having thrown down the sulphate of lime, pour the mixture on a filter, and test the filtered solution with *oxalate of ammonia* (218); sufficient of the sulphate will have been retained in solution to give a very perceptible precipitate with the oxalate.

217. *Phosphate of soda* ($2NaO, HO, PO_3$) gives, in neutral or alkaline solutions of lime, a white precipitate of phosphate of lime ($8CaO, 3PO_3$) which is readily soluble in dilute hydrochloric acid, and reprecipitated from the acid

solution when neutralized with ammonia.* The presence of ammonia does not, as in the case of magnesia, facilitate the formation of this precipitate.

218. (C) *Oxalate of ammonia* ($\text{NH}_4\text{O}, \text{C}_2\text{O}_3$) is an extremely delicate test for lime. When added to a solution containing it even in a highly diluted state, a copious white precipitate of oxalate of lime ($\text{CaO}, \text{C}_2\text{O}_3 + 2\text{Aq}$) is produced, which is one of the most insoluble salts with which we are acquainted.



It is necessary that the solution should contain no excess of acid, as the oxalate of lime is soluble in acid solutions; acetic and oxalic acids, however, do not dissolve it.

219. If alcohol, containing a salt of lime in solution, is burnt, the flame has a reddish tinge, less crimson, however, than that caused by strontia under the same circumstances (236). The salts of lime also communicate a similar color to the blowpipe flame.

SECTION III.

Baryta (BaO).

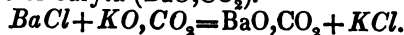
A solution of chloride of barium ($\text{BaCl} + 2\text{Aq}$) may be used with the liquid tests.

220. *Hydrosulphuric acid* and *hydrosulphate of ammonia* produce no precipitate with salts of baryta.

221. *Ammonia*, when free from carbonate, gives no precipitate.

222. *Potash* (KO) in dilute solutions, gives no precipitate; but if the baryta solution be concentrated, it throws down a bulky crystalline precipitate of hydrate of baryta ($\text{BaO}, \text{HO}, + 9\text{Aq}$), which redissolves if water be added.

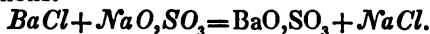
223. *Carbonate of Potash* (KO, CO_2), or carbonate of ammonia ($2\text{NH}_4\text{O}, 3\text{CO}_2$), throw down a white precipitate of carbonate of baryta (BaO, CO_2).



* If the phosphate of soda be added drop by drop to an excess of chloride of calcium, the precipitate consists of ($2\text{CaO}, \text{HO}, \text{PO}_3$).

When sesquicarbonate of ammonia is used, the solution should be mixed with a little free ammonia, and boiled, to decompose any bicarbonate of baryta, which, if present, would remain dissolved. The precipitated carbonate is readily soluble with effervescence in dilute hydrochloric or nitric acid.

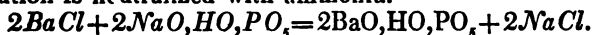
224. (C) *Sulphuric acid* (HO,SO_3) and *sulphate of soda* (NaO,SO_3) produce in solutions of baryta a copious white precipitate of sulphate of baryta (BaO,SO_3) even in very dilute solutions.



This precipitate is quite insoluble in hydrochloric and nitric acids, and thus differs from the carbonate formed in the last experiment.

225. (C) Solution of *sulphate of lime* (CaO,SO_3) throws down an immediate precipitate of sulphate of baryta (BaO,SO_3). This is the most convenient form of applying a very dilute solution of a sulphate (sulphate of lime requiring about 500 times its weight of water to dissolve it), and serves to distinguish baryta from strontia (233).

226. *Phosphate of soda* ($2NaO,HO,PO_3$) causes a white precipitate of phosphate of baryta ($2BaO,HO,PO_3$), which is soluble in free acids, but is reprecipitated when the acid solution is neutralized with ammonia.



The presence of ammoniacal salts does not affect the formation of this precipitate.

227. *Oxalate of ammonia* (NH_4O,C_2O_3) throws down a white crystalline precipitate of oxalate of baryta (BaO,C_2O_3) if the solution is not very dilute (184). It requires a much stronger solution of baryta than of lime to cause a precipitate with oxalate of ammonia. The oxalate of baryta, like that of lime, is readily soluble in free acids.

228. The flame of alcohol, containing a baryta salt, has a yellowish color, in which respect it differs from lime and strontia (219, 236).

SECTION IV.

Strontia (SrO).

A solution of nitrate of strontia (SrO, NO_3) may be used.

229. Neither *hydrosulphuric acid* nor *hydrosulphate of ammonia* produces any precipitate in solutions of strontia.

230. *Ammonia* and *potash* behave with solutions of strontia as with those of baryta; from concentrated solutions potash throws down the white hydrate of strontia (SrO, HO).

231. *Alkaline carbonates* also act as with solutions of baryta (223), carbonate of strontia (SrO, CO_2) being produced.

232. (C) *Sulphuric acid* (HO, SO_3) and *sulphate of soda* (NaO, SO_3) throw down a white precipitate of sulphate of strontia (SrO, SO_3) immediately, if the solution is not very dilute, and after standing a short time if it is so; in the latter case the precipitated sulphate is in the form of minute crystals.



233. (C) Solution of *sulphate of lime* (CaO, SO_3) gives no immediate precipitate in solutions of strontia, but if allowed to stand, sulphate of strontia gradually separates. Strontia may thus be distinguished from baryta (225).

234. *Phosphate of soda* ($2\text{NaO}, \text{HO}, \text{PO}_3$) behaves with solutions of strontia as with those of baryta (226).

235. *Oxalate of ammonia* ($\text{NH}_4\text{O}, \text{C}_2\text{O}_3$) gives a white precipitate of oxalate of strontia, in strong solutions, but not in dilute.

236. The flame of alcohol in which a salt of strontia is dissolved, or which contains some of the aqueous solution, assumes a beautiful carmine color, especially if the mixture is stirred. The color of this flame should be compared with that produced when the alcohol contains lime (219). When a salt of strontia is heated before the blowpipe, the same carmine color is communicated to the flame.

Summary of Class II.

237. Supposing we have in solution a salt of one of the metals belonging to this class, viz. : magnesia, lime, baryta, or strontia, we should be able without any difficulty, by applying a few of the most characteristic tests, to ascertain which individual of the class it is. Thus we should find that a solution of hydrosulphate of ammonia gave no precipitate, and that an alkaline carbonate gave a white one; from which we should infer that the metal belongs to Class II. We might then test it with a solution of sulphate of lime, which would tell us whether baryta or strontia were present (225); if not, add to a very dilute solution a little oxalate of ammonia, which, if the base were lime, would throw it down as oxalate (218). If neither of these tests gives any indication, add phosphate of soda and ammonia, when, if the base is magnesia, the double phosphate of ammonia and magnesia is precipitated (206).

Before finally deciding, however, that the base is either of these, it is always necessary to apply other confirmatory tests in addition to those just mentioned.

CHAPTER -IV.

METALS BELONGING TO CLASS III.

Alumina, Oxide of Chromium, Oxide of Zinc, Protoxide of Manganese, Protoxide of Iron, Peroxide of Iron, Oxide of Nickel, and Oxide of Cobalt.

238. The metals of the third class are distinguished from those of the first and second, in being precipitated from their neutral solutions by hydrosulphate of ammonia; and from those of the fourth class in being unaffected (with the partial exception of peroxide of iron (278)) when their solutions, containing a slight excess of acid, are treated with hydrosulphuric acid.

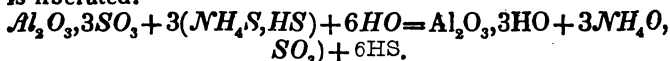
SECTION I.

Alumina (Al_2O_3).

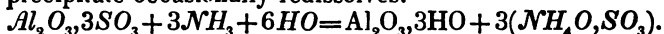
A solution of sulphate of alumina ($\text{Al}_2\text{O}_3, 3\text{SO}_3 + 18\text{Aq}$) may be used.

239. *Hydrosulphuric Acid* gives no precipitate either in a neutral or acid solution of alumina.*

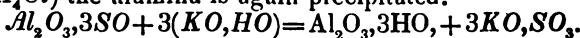
240. (C) *Hydrosulphate of Ammonia* ($\text{NH}_4\text{S}, \text{HS}$) when added to a neutral solution, gives a white precipitate of hydrate of alumina ($\text{Al}_2\text{O}_3, 3\text{HO}$), and hydrosulphuric acid is liberated.



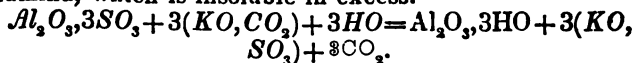
241. (C) *Ammonia* (NH_3) throws down a bulky white gelatinous precipitate, which consists chiefly of hydrate of alumina ($\text{Al}_2\text{O}_3, 3\text{HO}$) with a small admixture of ammonia, and a basic salt of alumina, which may be said to be insoluble in an excess of ammonia, although with a very large excess, and under peculiar circumstances, a portion of the precipitate occasionally redissolves.



242. (C) *Potash* (KO) also gives a precipitate of hydrate of alumina, which, like that caused by ammonia, usually contains a little basic salt: it differs from it, however, in being entirely soluble in an excess of the precipitant. If the solution in potash is mixed with muriate of ammonia (NH_4Cl) the alumina is again precipitated.



243. *Carbonate of potash* (KO, CO_2) and carbonate of ammonia ($2\text{NH}_4\text{O}, 3\text{CO}_2$) give a precipitate of hydrate of alumina, which is insoluble in excess.



244. *Sulphuric acid* and *sulphate of soda* give no precipitate in solutions of alumina.

* In most cases of qualitative analysis, hydrosulphuric acid may be applied in the state of solution in water (729).

245. (C) If a salt containing alumina be moistened with a solution of nitrate of cobalt (CoO, NO_3) and heated on charcoal before the blowpipe, it assumes a beautiful sky blue color, which is very characteristic, as no other substance gives so decided a color, though silica acquires under the same circumstances a tint somewhat similar, but much less intense. The blue color is best seen by daylight, after the mass has cooled, as by candle light it appears violet.

SECTION II.

*Oxide of Chromium (Cr_2O_3).**

A solution of sulphate of chrome ($Cr_2O_3, 3SO_3$) may be used.

246. *Hydrosulphuric acid* produces no precipitate either in neutral or acid solutions.

247. (C) *Hydrosulphate of ammonia* (NH_4S, HS) when added to neutral solutions of oxide of chromium, throws down a dark green precipitate of hydrated oxide of chromium ($Cr_2O_3, 3HO$), which is insoluble in excess.

248. (C) *Ammonia* (NH_3) also produces the same precipitate ($Cr_2O_3, 3HO$), a small portion of which redissolves in an excess of ammonia, forming a pale pinkish solution, but is again precipitated when the mixture is boiled.

249. (C) *Potash* (KO) also throws down the hydrated oxide, which is soluble in excess, forming a green solution; if the alkaline solution be boiled for a length of time, the hydrated oxide is again precipitated, leaving the liquid colorless.

250. *Carbonate of potash* (KO, CO_2) gives a dull green precipitate of subcarbonate of chromium, which redissolves in a large excess of the precipitant.

* It is remarkable that several of the compounds, both soluble and insoluble, of oxide of chromium, which are green by daylight, appear of a reddish purple color when seen by candlelight. This peculiar form of dichroism is seen to great advantage in a solution of the oxalate of chrome, which is green by daylight, but if held between a candle and the eye, appears purplish crimson. What is still more remarkable is, that if a green object, such as a tree or field, be viewed by daylight through the green solution, it appears of a bright reddish purple color.

251. (C) Oxide of chromium, when heated before the blowpipe with borax or microcosmic salt, either in the inner or outer flame, fuses into an emerald-green bead.

252. (C) If it is heated with a mixture of *nitrate of potash* (KO, NO_3) and *carbonate of soda* (NaO, CO_2), a yellow bead of alkaline chromate is formed. Here a portion of the oxygen of the nitric acid combines with the oxide of chromium (Cr_2O_3), converting it into chromic acid (Cr_2O_6), or rather (CrO_3), which combines with the potash or soda, forming an alkaline chromate (KO, CrO_3). If the bead be dissolved in water acidulated with a little nitric acid, the solution will give with salts of lead a bright yellow precipitate of chromate of lead (PbO, CrO_3) (363).

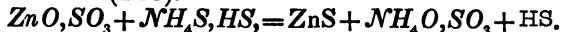
SECTION III.

Oxide of Zinc (ZnO).

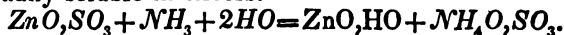
A solution of sulphate of zinc ($\text{ZnO}, \text{SO}_3 + 7\text{Aq}$) may be used.

253. *Hydrosulphuric acid* (HS), when added to a neutral solution of zinc, causes the precipitation of a portion of it as sulphide (ZnS). This test, however, for reasons which will afterwards appear (541), is usually applied to solutions containing a slight excess of hydrochloric or some other acid. For this purpose, acidify a little of the solution in a test-tube with a drop or two of hydrochloric acid (HCl) and then test it with hydrosulphuric acid; it will in this case produce no precipitate.

254. (C) *Hydrosulphate of ammonia* ($\text{NH}_4\text{S}, \text{HS}$) when added to a neutral or alkaline solution of zinc, gives a copious curdy precipitate of sulphide (ZnS), which if the zinc salt be pure, is white; but if, as is frequently the case, any iron is present, the precipitate will be more or less colored, owing to the admixture of a little of the black sulphide of iron (FeS).



255. (C) *Ammonia* (NH_3) throws down a white gelatinous precipitate of hydrated oxide of zinc (ZnO, HO), which is readily soluble in excess.



Prepare a few of these spots for comparison with those of arsenic formed in (315).

320. (C) Apply the heat of a spirit lamp to one of each kind of spot, and observe the superior volatility of the arsenic, and the garlic odor of its vapor.

321. (C) Moisten one of each kind of spot with hydro-sulphate of ammonia (NH_4S, HS), which for this purpose should contain an excess of sulphur (739), and observe that the antimony is *immediately dissolved*, while the arsenic remains nearly unaffected for a considerable length of time. This is a most valuable means of distinguishing between them, and was first observed by Dr. Guy.

322. (C) If the spots be moistened with a solution of chloride of lime ($CaOCl$), the arsenic will dissolve, while the antimony will remain unaffected.

323. (C) The following may also be taken as a distinguishing test between arsenic and antimony when Marsh's process is followed. Light the jet of gas issuing from the apparatus, and hold over it a short tube as in (316), so as to collect a little of the oxide of antimony (SbO_3) formed by the oxidation of the antimonial vapor. Compare the sublimate thus formed, with that of arsenious acid, and observe the more crystalline appearance of the latter. When the tube is cold, pour in a little water, and treat the arsenious acid in the same way: observe that the latter dissolves in the water, while the oxide of antimony remains insoluble. The solution of arsenious acid may then be divided into three portions and tested; the first with *hydro-sulphuric acid* (307); the second with *ammonio-nitrate of silver* (310); and the third with *ammonio-sulphate of copper* (311).

These experiments, in conjunction with the other liquid tests, will be found sufficient to prevent the possibility of error in the use of Marsh's test.

Reinsch's Test.

324. (C) This test is founded on the circumstance that when a metal, such as copper, is heated in a solution of another metal more electro-negative than itself, the latter is separated in the metallic state, and deposited on the surface of the former, which is at the same time dissolved

fied solution (formed by adding a few drops of hydrochloric acid to a little of the solution in a test-tube), gives no precipitate. If the solution is neutral, a partial precipitation of sulphide (MnS) takes place.

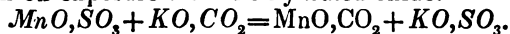
263. (C) *Hydrosulphate of ammonia* (NH_4S, HS) gives in neutral solutions a flesh-colored gelatinous precipitate of sulphide of manganese (MnS), which is insoluble in excess. If this precipitate be exposed to the air, it is gradually decomposed, and is converted into the dark brown hydrated sesquioxide ($Mn_2O_3, 2HO$) in consequence of the strong affinity of manganese for oxygen, which it absorbs from the air.

264. (C) *Ammonia* (NH_3) throws down a white or pale flesh colored precipitate of hydrated protoxide of manganese (MnO, HO), which if exposed to the air becomes brown, owing to the formation of the sesquioxide ($Mn_2O_3, 2HO$) as in the last experiment. $2(MnO, HO) + O = Mn_2O_3, 2HO$.

If muriate of ammonia (NH_4Cl) is present in the solution, it prevents the precipitation of the hydrated protoxide; or, if added subsequently, redissolves it, owing to the formation of double salts of ammonia and manganese which are soluble in water. If the ammoniacal solution be exposed to the air, the brown sesquioxide is gradually precipitated.

265. *Potash* (KO) behaves as ammonia in solutions of manganese: the presence of muriate of ammonia, however, does not altogether prevent the precipitation of the protoxide.

266. *Carbonate of potash* (KO, CO_2) or of ammonia ($2NH_4O, 3CO_2$) throws down a white precipitate of carbonate of manganese (MnO, CO_2) which is less prone to blacken on exposure than the hydrated oxide.



267. (C) When compounds of manganese are mixed with carbonate of soda (NaO, CO_2) and heated on platinum wire in the outer flame of the blowpipe, the manganese becomes more highly oxidized, and is changed into manganic acid (MnO_3); this combines with the soda to form manganate of soda (NaO, MnO_3) which has a characteristic green color. The change is produced still more rapidly if a little nitrate of potash (KO, NO_3) be added to the mixture.

268. (C) When mixed with borax ($NaO, 2BO_3 + 10Aq$) or

microcosmic salt ($\text{NaO}, \text{NH}_4\text{O}, \text{HO}, \text{PO}_5 + 8\text{Aq}$) and heated in the outer flame of the blowpipe, the salts of manganese form beads of an amethyst purple color, which is due to the formation of the red oxide (Mn_2O_3). If the mixture be heated in the inner flame, the color disappears, owing to the reconversion of the red oxide into protoxide (MnO): this loss of color takes place most readily with microcosmic salt.

SECTION V.

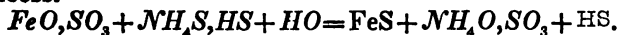
Protoxide of Iron (FeO).

A solution of protosulphate of iron ($\text{FeO}, \text{SO}_3 + 7\text{Aq}$) may be used.

269. On account of the strong tendency of the protoxide of iron to absorb oxygen on exposure to the air, and become sesquioxide, especially in aqueous solutions of its salts, it is difficult to retain the protosalts in solution without some admixture of sesquioxide; so that in testing them, the indications of some of the reagents are frequently more or less different from those caused by a pure protosalt. If the solution of a protosalt be boiled with nitric acid, the protoxide is wholly converted into peroxide. $6\text{FeO} + \text{NO}_3 = 3\text{Fe}_2\text{O}_3 + \text{NO}_2$.

270. *Hydrosulphuric acid* (HS) produces no precipitate in acidified solutions of protoxide of iron: a slight precipitation of sulphide (FeS) takes place, however, in neutral solutions of some of its salts, especially when the acid with which it is in combination is a feeble one.

271. *Hydrosulphate of ammonia* ($\text{NH}_4\text{S}, \text{HS}$) when added to neutral solutions of protoxide of iron, throws down a black precipitate of sulphide (FeS), which is insoluble in excess.



272. (C) *Ammonia* (NH_3) gives a precipitate of hydrated protoxide of iron (FeO, HO) which is at first nearly white, but almost immediately becomes greenish. If this precipitate be exposed to the air, it absorbs oxygen, and is changed into hydrated sesquioxide or peroxide ($\text{Fe}_2\text{O}_3, 3\text{HO}$) which

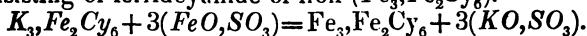
has a reddish brown or rust color. Muriate and some other salts of ammonia, prevent the precipitation of the protoxide by ammonia, forming a solution of a double salt of ammonia and iron, from which the hydrated peroxide is gradually precipitated if exposed to the air.

273. *Potash* (KO) behaves as ammonia.

274. *Carbonate of potash* (KO, CO_2) produces a precipitate of carbonate of iron (FeO, CO_2) which is similar in appearance to the hydrated protoxide (272).

275. (C) *Ferrocyanide of potassium* ($K_2FeCy_3 + 3Ag$)* throws down in solutions of protoxide of iron, a precipitate (KFe_32FeCy_3) which is at first almost white, but rapidly changes to pale blue; the color becomes darker on exposure to the air, owing to the absorption of oxygen, which combines with the potassium and a portion of the iron, forming at the same time Prussian blue (Fe_43FeCy_3) (282). This change takes almost immediately if a little nitric acid or chloride of lime be added to the mixture.

276. (C) *Ferridcyanide of potassium* (K_3, Fe_2Cy_6)† produces in solutions of the protosalts of iron, a beautiful dark blue precipitate, similar in appearance to Prussian blue, consisting of ferridcyanide of iron (Fe_3, Fe_2Cy_6).



277. When heated with borax before the blowpipe, salts of iron form beads which in the oxidizing flame become orange, and in the reducing flame green; the color being due to the iron in a higher or lower state of oxidation.

SECTION VI.

Peroxide or Sesquioxide of Iron (Fe_2O_3).

A solution of the perchloride of iron (Fe_2Cl_3) may be used.

278. *Hydrosulphuric acid* (HS) causes in neutral or acidified solutions of the persalts of iron, a slight precipitation of sulphur, which gives the solution a milky ap-

* Ferrocyanogen ($FeCy_3$) which is here combined with potassium, is a hypothetical radical composed of iron in a peculiar state of combination with cyanogen (C_2N). See DANIELL'S *Chemical Philosophy*, p. 657.

† Ibid. p. 658.

pearance. This is owing to the decomposition of the hydrosulphuric acid by the peroxide of iron, the hydrogen combining with a portion of its oxygen, reducing it to the state of protoxide, while the liberated sulphur is precipitated in a finely divided state.

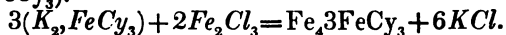


279. *Hydrosulphate of ammonia* ($\text{NH}_4\text{S}, \text{HS}$) separates the whole of the iron from solutions of its persalts, as the black sulphide (FeS), the same compound as that produced in the protosalts. The peroxide (Fe_2O_3) is in fact first converted into the protoxide (FeO) by the deoxidizing affinity of the hydrogen and sulphur in the hydrosulphate, so that the subsequent change is the same as that produced in the protosulphate (271). If the solution of iron is very dilute, no precipitate appears at first, but the solution becomes green, and if allowed to stand a considerable time, the sulphide gradually separates.

280. (C) *Ammonia* (NH_3) throws down the hydrated peroxide of iron ($\text{Fe}_2\text{O}_3, 3\text{HO}$), in the form of a bulky reddish brown precipitate, which is insoluble in an excess of ammonia, and is unaffected by the presence of ammoniacal salts.

281. *Potash* (KO) produces the same precipitate ($\text{Fe}_2\text{O}_3, 3\text{HO}$), which is insoluble in excess.

282. (C) *Ferrocyanide of potassium* ($\text{K}_2\text{FeCy}_3 + 3\text{Ag}$)* produces in solutions of the persalts of iron a beautiful precipitate of sesquiferrocyanide of iron, or Prussian blue ($\text{Fe}_43\text{FeCy}_3$).



This is an extremely delicate and characteristic test for the persalts of iron, as the precipitate is produced even in very dilute solutions.

283. *Ferridcyanide of potassium* ($\text{K}_3, \text{Fe}_2\text{Cy}_6$) produces no precipitate with persalts of iron; it gives, however, a deep green color to the solution.

284. When heated before the blowpipe, the persalts of

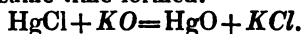
* In testing for iron with ferrocyanide of potassium, it must be borne in mind that when added to a solution containing much free acid, it is partially decomposed, and a little Prussian blue is formed, even when no iron is present. As the presence of free alkalis also interferes with the formation of the blue precipitate, solutions to be tested with it should be as nearly neutral as possible.

and minute globules of metallic mercury condense in the cool part of the tube at *c*.

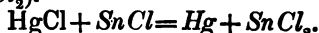


337. Boil a little calomel with distilled water in a test-tube; pour off the water into another tube, and test it with hydrosulphate of ammonia (340); no effect is produced, proving that the calomel is insoluble in water.

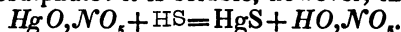
338. (C) *Potash* (KO) or *ammonia* (NH₃) poured on the calomel, decomposes it, turning it black, owing to the formation of the protoxide (HgO). Chloride of potassium (KCl) is at the same time formed.



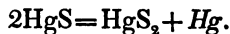
339. (C) Boil a little calomel in fine powder with a solution of *protochloride of tin* (SnCl): after some little time the mercury is reduced to the metallic state, owing to the strong affinity which the protochloride of tin has for an additional equivalent of chlorine, which converts it into the bichloride (SnCl₂).



340. (C) when a solution, either neutral or acid, containing protoxide of mercury, is treated with *hydrosulphuric acid* (HS) or *hydrosulphate of ammonia* (NH₃S, HS), a black precipitate of protosulphide of mercury (HgS) is thrown down, which is insoluble in dilute acids and also in excess of the hydrosulphate: it is soluble, however, in aqua regia.

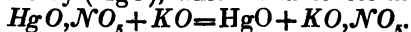


If the precipitate, after being dried, be heated alone in a tube, it is decomposed into metallic mercury and the persulphide (HgS₂).

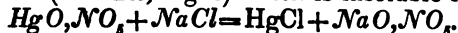


341. *Ammonia* (NH₃) gives a black precipitate, consisting of a basic double salt of mercury and ammonia (NH₃, 3HgO, NO₃), which is insoluble in excess.

342. *Potash* (KO) produces a black precipitate of protoxide of mercury (HgO), which is insoluble in excess.

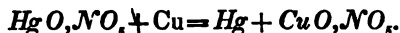


343. (C) *Hydrochloric acid* (HCl), or a solution of *chloride of sodium* (NaCl), throws down a white precipitate of protochloride (calomel, HgCl) which is insoluble in excess.



344. (C) Place a strip of clean *copper* in the mercurial

solution, and observe the deposition of metallic mercury (324).



If the stain be rubbed, it will become bright and silvery. Dry the stained copper, place it in a dry tube, and apply heat: the mercury sublimes, and condenses in minute globules in the upper part of the tube.

SECTION IV.

Peroxide of Mercury (HgO₂).

The perchloride of mercury or corrosive sublimate (HgCl₂), either solid or in solution, may be used.

345. (C) Heat a small fragment of the perchloride in a tube: it fuses, boils, and sublimes into the upper part of the tube. If the experiment be made on charcoal, the whole is volatilized.

346. (C) Repeat the experiment described in (336), using the perchloride instead of calomel; metallic mercury sublimes in both cases.

347. Boil a little with water, in which it readily dissolves, thus differing from the protochloride.

348. (C) Test a solution of the perchloride with a small quantity of *hydrosulphuric acid* (HS). A white precipitate is first formed, which on the addition of more of the precipitant, gradually becomes darker, and ultimately black. This change of color is owing to the formation first of a double compound of sulphide and chloride of mercury (2HgS₂, HgCl₂), which is white, and when the hydrosulphuric acid is added in excess, the whole of the mercury is converted into the black persulphide (HgS₂). The precipitate is insoluble in hydrochloric and nitric acids, but is readily decomposed by aqua regia, and again converted into the perchloride.

If the persulphide be dried and cautiously sublimed in a tube, it is deposited, without decomposition, in the form of dark red crystals of cinnabar.

349. (C) *Hydrosulphate of ammonia* (NH₄S, HS) behaves in the same way as hydrosulphuric acid.

296. (C) *Ammonia* (NH_3) behaves as potash, but the precipitate readily redissolves in an excess, forming double salts of cobalt and ammonia, which are soluble in water. If the ammoniacal solution is exposed to the air, it gradually becomes darker, owing to the absorption of oxygen, and formation of peroxide of cobalt (Co_2O_3).

297. *Carbonate of potash* (KO, CO_2) produces a pale pink precipitate, which is a mixture of carbonate of cobalt (CoO, CO_2) and hydrated oxide (CoO, HO).

298. (C) *Cyanide of potassium* (KCy) when added to a solution of cobalt, especially when a slight excess of hydrochloric acid is present, gives a pale brown precipitate of cyanide of cobalt ($CoCy$), which when heated with an excess of cyanide of potassium readily redissolves, forming a soluble double cyanide of cobalt and potassium ($K_3Co_2Cy_6$). The addition of sulphuric acid causes no precipitate in this solution (291).

299. (C) The compounds of cobalt, when fused with borax ($NaO, 2BO_3 + 10Aq$), either in the inner or outer flame of the blowpipe, form beads of an intense blue color, or if there is much cobalt present, nearly black; this appearance is very characteristic. Microcosmic salt acts with cobalt in a similar manner, but in a less marked degree. When mixed with carbonate of soda, and heated on charcoal in the deoxidizing flame, oxide of cobalt is reduced to the metallic state, forming a magnetic powder.

CHAPTER V.

METALS BELONGING TO CLASS IV.

Arsenic, (of which there are two oxides, both having acid properties; namely, arsenious acid and arsenic acid,) oxide of antimony, protoxide of mercury, peroxide of mercury, oxide of lead, oxide of copper, oxide of silver, protoxide of tin, peroxide of tin, and oxide of bismuth.

300. These metals are distinguished from those of the three preceding classes, by being precipitated from their

acidified solutions when treated with hydrosulphuric acid. It is remarkable that nearly all the metals whose compounds are most eminently poisonous, belong to this class; and as these are the most important, especially to the medical student, they are placed first, and described in the order of their importance. The oxides of arsenic, though possessing acid properties, and consequently belonging strictly to the chapter on acids, have so many peculiarities in common with this class of oxides that I have included them in it.

SECTION I.

Arsenious Acid or Oxide of Arsenic (AsO_3).

301. (C) If a small fragment of arsenious acid* be heated on charcoal before the blowpipe, it is wholly volatilized, and a smell of garlic will generally be perceptible, especially when it is subjected to the reducing flame. Both metallic arsenic and its oxide are volatile when heated, but the fumes of the latter have no smell. The odor of arsenic vapor appears to be due to the metal while undergoing oxidation, and may be caused perhaps by the formation of a lower oxide than the arsenious acid; it is always observable when metallic arsenic is volatilized in contact with the air.

302. (C) Place a fragment of arsenious acid in a narrow tube (102), and apply a gentle heat with the blowpipe. It sublimes without decomposition, and condenses in the cool part of the tube,

Fig. 67.



* On account of the highly poisonous nature of arsenic, great care should be taken in these experiments not to use more than is absolutely necessary to exhibit its peculiarities. In all these experiments (except those of solution) a fragment the size of a small pin's head is quite sufficient. There is also another advantage in using such small quantities; namely, that in most medico-legal investigations, the quantity to be looked for is equally or even more minute, and it is consequently very important that the student should make himself familiar with the appearances which would under these circumstances present themselves.

in the form of minute sparkling octahedral crystals, which should be examined with a lens, as they are highly characteristic.

303. (C.) Mix a little oxide of arsenic (AsO_3) with black flux (780), which if at all damp should be previously dried on the sandbath, and heat a little of the mixture in a clean tube before the blow-pipe. The arsenious acid is deoxidized by the carbon of the flux, and the metallic arsenic thus reduced sublimes, and condenses in the upper part of the tube, forming a more or less brilliant metallic crust. $\text{AsO}_3 + 3\text{C} = \text{As} + 3\text{CO}$.

Fig. 68.



If heat be now applied to the sublimate, it will again volatilize, and if any of the vapor escapes from the tube, it may be recognized by its characteristic odor of garlic.

304. (C) Cut off by means of a file, the portion of the tube containing the crust, break it into fragments, and place some of them in another tube. Sublime the arsenic backwards and forwards two or three times in the tube, and observe the gradual conversion of the metal into crystalline arsenious acid, which is formed by the action of the atmospheric oxygen contained in the tube.

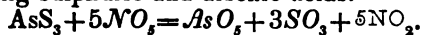
305. Boil a few grains of arsenious acid with water, (in which it is sparingly soluble,) in a flask: filter the solution from the undissolved portion, and retain it for testing.

306. Repeat the last experiment, with the addition of a few drops of solution of potash (KO) to the water, and observe the increased solubility of the arsenic, owing to the formation of arsenite of potash (KO, AsO_3). Retain the solution for testing.

307. (C) *Hydrosulphuric acid* (HS) when passed through a solution of arsenious acid or of a neutral arsenite, causes a slow and gradual precipitation of tersulphide of arsenic, or sulpharsenious acid (AsS_3), which it will be observed is analogous in composition to the oxide (AsO_3), three equivalents of sulphur being substituted for three equivalents of oxygen. $\text{AsO}_3 + 3\text{HS} = \text{AsS}_3 + 3\text{HO}$.

If the solution be acidified, however, with a few drops of hydrochloric acid, a much more rapid and complete decomposition takes place; and if the gas be passed through

the solution for some time, a complete separation of the arsenic may in this way be effected. The sulphide of arsenic thus formed has a bright light yellow color; it is insoluble or nearly so in dilute hydrochloric acid, but readily soluble in solutions of the alkalies or their carbonates. Boiling nitric acid (HNO_3) also dissolves it with decomposition, forming sulphuric and arsenic acids.



308. (C) Filter the yellow sulphide formed in the last experiment, and dry a portion of it at a gentle heat on the sandbath: mix a little of it with black flux (303), heat it in a tube, and observe the formation of a metallic crust of arsenic. $\text{AsS}_3 + 3(\text{K}_2\text{O}, \text{CO}_2) + 2\text{C} = \text{As} + 3\text{K}_2\text{S} + 4\text{CO}_2 + \text{CO}.$

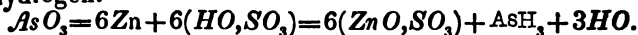
309. *Hydrosulphate of ammonia* ($\text{NH}_4\text{S}, \text{HS}$), when added to a neutral solution of an arsenite, also causes the formation of the yellow sulphide (AsS_3) which, however, does not precipitate, but remains dissolved as the double sulphide of arsenic and ammonium ($\text{NH}_4\text{S}, \text{AsS}_3$). If an acid be added in excess to the mixture, the sulphide of arsenic is immediately precipitated, of a somewhat lighter color than that thrown down by hydrosulphuric acid, owing to the admixture of a little sulphur derived from the hydrosulphate of ammonia (440).

310. (C) *Nitrate* (AgO, HNO_3) or *ammonia-nitrate* ($\text{AgO}, 2\text{NH}_3, \text{HNO}_3$) of silver, throws down in neutral solutions of arsenic, a canary colored precipitate of arsenite of silver ($2\text{AgO}, \text{AsO}_3$), which is soluble both in ammonia and nitric acid. It must be remembered that *phosphate of soda* also produces, with nitrate of silver, a similar precipitate, which is equally soluble in nitric acid and ammonia (378).

311. (C) *Sulphate* ($\text{CuO}, \text{H}_2\text{SO}_4$), or *ammonio-sulphate* ($\text{CuO}, 2\text{NH}_3, \text{H}_2\text{SO}_4$) of copper, produces in neutral arsenical solutions, a delicate green precipitate of arsenite of copper ($2\text{CuO}, \text{AsO}_3$), which is readily soluble both in ammonia and nitric acid. It must be borne in mind in employing this test, that a similar precipitate is produced when the solution of copper is added to a liquid containing decoction of onions and some other vegetable substances, though no arsenic may be present.

Marsh's Test.

312. (C) It is well known that when zinc is treated with dilute sulphuric acid, it is oxidized at the expense of the oxygen of the water, and hydrogen gas is given off (12). If in addition to the zinc and dilute sulphuric acid, either of the oxides of arsenic is present, the zinc abstracts oxygen from them as well as from the water, and the metallic arsenic thus formed, combines, at the moment of its liberation, with some of the hydrogen simultaneously produced, and forms a gaseous compound called *arseniuretted hydrogen* (AsH_3), which passes off mixed with excess of hydrogen.*



Now if this arseniuretted hydrogen is heated strongly, either by burning in the air, or by passing through a red-hot tube, it is decomposed, and metallic arsenic or its oxide is deposited in the solid state, while the liberated hydrogen passes off.

313. Several forms of apparatus have been contrived for making use of this property in the detection of arsenic: of these the following is in practice the most convenient.

Fig. 69.



The bottle *a* should be capable of containing six or eight ounces of water, and is connected by means of a perforated cork with the tubes *b* and *c*, which should be about half an inch in diameter: to the latter is attached by means of a cork, the tube *d*, which should be made of hard German glass, bent at a right angle, having the end

e drawn off so as to diminish the aperture. A few fragments of zinc are placed in the bottle, and when the cork

* It must be borne in mind that this gas, like most of the other compounds of arsenic, is highly poisonous, so that the experiment should never be performed in a close room, but in the open air or in a well-ventilated apartment.

with its tubes is attached, pour a little dilute sulphuric acid down the tube *b*, which should reach nearly to the bottom of the bottle, and allow the gas (hydrogen) to be given off for five minutes.* Then heat the narrow tube with a spirit lamp at the point *d*, and observe carefully whether there is any deposit produced inside the tube: this precaution is necessary, since some kinds of sulphuric acid, and also of zinc, contain traces of arsenic. If no stain is produced, it may be assumed that the materials are pure.

314. The solution containing (or suspected to contain) arsenic, is now introduced through the tube *b*, the heat being still applied to the narrow tube at *d*, as before. If arsenic is present in the liquid, it will cause the formation of arseniuretted hydrogen, which, on passing through the heated tube is decomposed, and the arsenic deposited, not exactly at the heated point, but a quarter or half an inch beyond, in consequence of its volatility. The metallic crust thus formed may be volatilized backwards and forwards in the tube by heating it with the flame of a spirit lamp.

315. (C) The arsenical crust may also be obtained in another way: namely, by lighting the jet of gas as it issues from the aperture *e*, and holding in the flame a small porcelain plate, (for which purpose the lid of a porcelain crucible answers extremely well,) when the metallic arsenic will be deposited in the form of a dark shining spot, if the porcelain plate be raised a little, so as to be out of the flame, the arsenic in the state of vapor becomes oxidized while passing through the air, and a white deposit of arsenious acid is formed on the plate. By applying heat to the dark spots, they are readily volatilized, and the fumes will be found to have the characteristic odor of garlic.

A few of these spots should be retained for further examination, and for comparison with those of antimony (320).

316. Hold a short test-tube with the mouth downwards, just above the apex of the flame for a few moments, so as to collect some of the arsenious acid formed by the oxi-

* The reason why it is not safe to apply the heat at once, is that a mixture of hydrogen and common air is highly explosive (17), so that it is necessary to allow time for the whole of the common air to be expelled by the hydrogen, as otherwise serious injury might be caused by an explosion of the mixed gases.

long been known as *purple of Cassius*; its composition appears to be $[2(\text{SnO}, \text{SnO}_2) + \text{AuO}_2, \text{SnO}_2 + 6\text{HO}]$. For the success of this experiment, it is necessary that both solutions be exceedingly dilute.

SECTION IX.

Peroxide of Tin (SnO_2).

A solution of the perchloride (SnCl_2) may be used.

387. (C) Salts of the peroxide of tin behave in the same manner before the blowpipe as those of the protoxide (379).

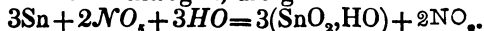
388. (C) *Hydrosulphuric acid* (HS) gives a yellow precipitate of persulphide of tin (SnS_2) which is soluble in solution of potash.

389. (C) *Hydrosulphate of ammonia* ($\text{NH}_4\text{S}, \text{HS}$) also throws down the yellow persulphide, which is readily soluble in excess.

390. *Ammonia* (NH_3) and *potash* (KO) throws down a bulky white precipitate of hydrated peroxide of tin (SnO_2, HO), which is soluble in an excess of the precipitant, especially when potash is used, forming a compound called stannate of potash (KO, SnO_2), in which the peroxide of tin appears to play the part of an acid.

The hydrated peroxide, when thus formed by precipitation with potash, is readily soluble both in potash and nitric acid, in which respect it differs from that formed by the action of nitric acid on metallic tin, though both yield the same results when analyzed (392).

391. (C) Pour a few drops of *nitric acid* upon a small fragment of metallic tin in a test-tube, and observe the intense action which immediately takes place. The nitric acid (NO_3) is decomposed by the affinity of the tin for a portion of its oxygen; the white hydrated peroxide of tin (SnO_2, HO) is formed; and nitric oxide (NO_2), and some of the other oxides of nitrogen, are given off.*



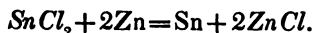
* A little ammonia is at the same time formed by the decomposition of water.



392. Heat the hydrated oxide formed in the last experiment, first with nitric acid and afterwards in a solution of potash, and observe that it is quite insoluble in both, thus differing from that formed by potash (390).

393. (C) If a piece of clean *zinc* be placed in a solution of perchloride of tin, the tin is separated in the metallic state, in the form of beautiful feathery crystals, some of which are so minute as to look like an amorphous spongy mass, but when examined with the microscope, appear as multitudes of brilliant and beautifully formed crystalline tufts.

Fig. 72.



SECTION X.

Oxide of Bismuth (Bi_2O_3).

A solution of the chloride (Bi_2Cl_3) may be used.

394. (C) Mix a concentrated solution of the chloride with a considerable quantity of *water*, which causes a white precipitate of oxichloride of bismuth ($\text{Bi}_2\text{Cl}_3, 2\text{Bi}_2\text{O}_3$).

A similar decomposition takes place when solutions of many of the soluble salts of bismuth are diluted with much water. The precipitates thus formed, are readily distinguishable from those produced under the same circumstances in solutions of antimony, by being insoluble in tartaric acid (332). They dissolve easily, however, in acetic acid.

395. (C) When the salts of bismuth are mixed with carbonate of soda, and heated in the reducing flame of the blowpipe, small globules of the metal are formed, which break with a crystalline fracture when struck with a hammer. In the oxidizing flame, with borax or microcosmic salt, oxide of bismuth forms a yellowish bead, which become nearly colorless on cooling.

396. *Hydrosulphuric acid* (HS), and *hydrosulphate of ammonia* ($\text{NH}_4\text{S}, \text{HS}$), throw down from solutions of bis-

muth, which do not contain a large excess of free acid, ~~==~~ black precipitate of sulphide of bismuth (Bi_2S_3), which is ~~==~~ insoluble in dilute acids and potash, but soluble in hot nitric ~~==~~ acid.

397. *Ammonia* (NH_3) and *potash* (KO) give a white precipitate of hydrated oxide ($\text{Bi}_2\text{O}_3, 3\text{HO}$) which is insoluble in an excess of the precipitant.

398. *Carbonate of potash* (KO, CO_2) gives a bulky white precipitate of subcarbonate of bismuth ($\text{Bi}_2\text{O}_3, \text{CO}_2$) which is insoluble in excess.

399. (C) When oxide of bismuth is heated, it turns yellow, and becomes colorless again on cooling.

CHAPTER VI.

ACTION OF REAGENTS WITH THE INORGANIC ACIDS.

400. THE inorganic acids, which are enumerated in paragraph (179), may be conveniently divided into three classes, according to their behavior with chloride of barium, and nitrate of silver, thus:—

Class I.—Acids which are precipitated by a solution of chloride of barium.

Sulphuric (HO, SO_3).		Carbonic (CO_2).
Phosphoric (PO_5).		Silicic (SiO_3).
Boracic (BO_3).		

Class II.—Acids which are unaffected by chloride of barium, but which are precipitated by a solution of nitrate of silver.

Hydrochloric (HCl), Hydriodic (HI), and Hydrosulphuric (HS).

Class III.—Those which are not precipitated either by chloride of barium or nitrate of silver.

Nitric (NO_5) and Chloric (ClO_5).

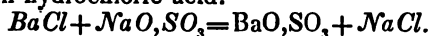
SECTION I.

Sulphuric Acid (HO, SO_3).

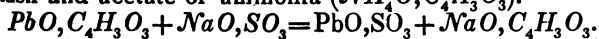
401. Mix a few drops of strong sulphuric acid or oil of vitriol, with about an equal quantity of water in a test-tube, and observe the heat evolved.

402. (C) Place a small bit of wood or paper in a test-tube, and pour upon it a few drops of oil of vitriol: the organic matter is decomposed, and a black carbonaceous matter is formed.

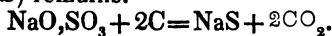
403. (C) Add a few drops of a solution of *chloride of barium* ($BaCl$) or *nitrate of Baryta* (BaO, NO_3) to one of sulphate of soda (NaO, SO_3): a heavy white precipitate of sulphate of baryta (BaO, SO_3) is thrown down, which is insoluble in hydrochloric acid.



404. (C) *Acetate of lead* ($PbO, C_4H_3O_3 + 3Ag$) throws down in solutions containing sulphuric acid, a dense white precipitate of sulphate of lead (PbO, SO_3), which is insoluble in dilute acids, but sparingly soluble in strong sulphuric and hydrochloric acids (720). It is soluble also in potash and acetate of ammonia ($NH_4O, C_4H_3O_3$).



405. (C) Mix a little dry sulphate of soda (NaO, SO_3) or some other sulphate, with black flux, and heat it on platinum wire in the reducing flame of the blowpipe: the oxygen both of the soda and acid is removed, and sulphide of sodium (NaS) remains.



406. (C) Place the bead formed in the last experiment, in a test-tube, and moisten it with a little dilute sulphuric acid: hydrosulphuric acid (HS) is given off, which may be recognized by its odor, or by putting into the tube a strip of paper moistened with a solution of acetate of lead, which will be blackened, owing to the formation of sulphide of lead (PbS) (438).

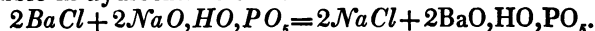


SECTION II.

Phosphoric Acid (tribasic) ($3\text{HO},\text{PO}_3$).

A solution of common tribasic phosphate of soda ($2\text{NaO}, \text{HO},\text{PO}_3 + 24\text{Aq}$) may be used.*

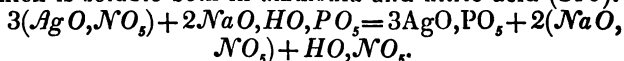
407. *Chloride of barium* (BaCl) throws down a white precipitate of phosphate of baryta ($2\text{BaO},\text{HO},\text{PO}_3$) which is soluble in hydrochloric acid.



408. *Chloride of calcium* (CaCl) gives a white precipitate of phosphate of lime ($8\text{CaO},3\text{PO}_3$), which readily dissolves in a slight excess of hydrochloric acid.†

409. (C) *Sulphate of magnesia* ($\text{MgO},\text{SO}_3 + 7\text{Aq}$) causes a white precipitate of phosphate of magnesia ($2\text{MgO},\text{HO},\text{PO}_3$), if the solution is tolerably strong. If a little ammonia or carbonate of ammonia, however, be present in the solution, the double phosphate of ammonia and magnesia ($2\text{MgO}, \text{NH}_4\text{O},\text{PO}_3 + 12\text{Aq}$) is formed, which being much more insoluble than the phosphate of magnesia, is precipitated in more dilute solutions, and is consequently a more delicate test. It separates as a granular crystalline precipitate, and is readily soluble in excess of acid (206).

410. (C) *Nitrate of silver* (AgO,NO_3) throws down a pale yellow precipitate of tribasic phosphate of silver ($3\text{AgO},\text{PO}_3$) which is soluble both in ammonia and nitric acid (310).



411. (C) Heat a small fragment of common tribasic phosphate of soda before the blowpipe; when cool, dissolve it in water, and add to the solution a few drops of *nitrate of silver*. Instead of the yellow tribasic phosphate of silver ($3\text{AgO},\text{PO}_3$) being thrown down as before, a white granular precipitate of the bibasic phosphate ($2\text{AgO},\text{PO}_3$) is produced. This is owing to the tribasic phosphate of soda

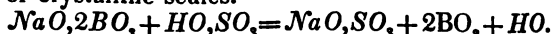
* The monobasic (HO,PO_3) and bibasic phosphoric acids ($2\text{HO},\text{PO}_3$), being rarely met with in analysis, are omitted.

† See note to (217).

SECRET

416. *Nitrate of silver* (AgO, NO_3) gives a white precipitate of borate of silver (AgO, BO_3), which is soluble both in ammonia and nitric acid.

417. (C) If *strong sulphuric acid* (HO, SO_3) be added to a concentrated solution of a borate, the boracic acid which is displaced, separates in combination with water in the form of crystalline scales.



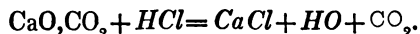
418. (C) If borax or any other borate, be moistened with a little *sulphuric acid*, and the mixture treated with *alcohol*, the boracic acid is dissolved, and communicates a green color to the flame when it is burnt. This is probably owing to a little of the boron (B) being deoxidized by the burning spirit, and recombining with oxygen as it comes in contact with the air at the edge of the flame.

SECTION IV.

Carbonic Acid (CO_2).

The physical and some of the chemical properties of carbonic acid, have been already noticed (18, &c.).

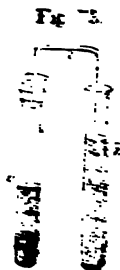
419. (C) The carbonates when treated with a *free acid*, as hydrochloric, are decomposed, and the carbonic acid being gaseous when uncombined, escapes with effervescence.



It may be distinguished from other gaseous acids by being inodorous. When a substance such as marble is tested in this way for carbonic acid, it is generally advisable to drench it with water; if this is not done, small bubbles of common air, which at first adhere to the solid substance, gradually escape, and may lead an inexperienced person to suppose that effervescence is taking place.

420. (C) When carbonic acid is passed into *lime water* (CaO), it causes a white precipitate of carbonate of lime (CaO, CO_2), most of which redissolves if the gas is passed through for a length of time, owing to the formation of the bicarbonate of lime ($CaO, 2CO_2$), which is soluble in water.

This experiment is best made in a test-tube *a*, to which is connected, by means of a perforated cork, a bent tube, *b*. A small lump of marble is put into *a*, and the tube *b* half filled with lime water: dilute hydrochloric acid is then poured upon the marble, and the bent tube attached, which conducts the liberated carbonic acid into the lime water, which it immediately renders turbid.



421. *Chloride of barium* $BaCl$ and *chloride of calcium* $CaCl$ throw down a white precipitate of carbonate of baryta $BaO.CO_2$ or of lime $(CaO.CO_2)$, which readily dissolves with effervescence in dilute hydrochloric acid.

422. *C. Subacetate of lead* $3PbO.C_2H_3O_5$ is an extremely delicate test for carbonic acid, with which it forms a white precipitate of carbonate of lead $(PbO.CO_2)$.

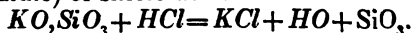
423. Most of the carbonates, except those of the alkalis, are decomposed when strongly heated, in which case the oxide or the reduced metal is left (122).

SECTION V.

Silicic Acid (SiO_2) .

There are two modifications of silicic acid, one of which is soluble, and the other insoluble.

424. (C) Add a little strong *hydrochloric acid* (HCl) to a concentrated solution of silicate of potash $(KO.SiO_2)$, and warm the mixture: a bulky precipitate separates, which is soluble in potash, while a portion remains dissolved in the acid solution; this is the soluble modification (probably a definite hydrate) of silicic acid.

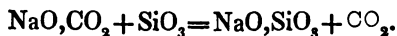


425. (C) Evaporate to dryness the solution with the precipitate, formed in the last experiment, and observe, that on again treating the residue with hydrochloric acid, the silicic acid remains undissolved; in this state it is almost insoluble also in cold alkaline solutions. Thus we find that

when the soluble modification of silicic acid is evaporated to dryness, it is converted into the insoluble modification.

426. (C) Mix a little dry silicic acid, or an insoluble silicate, in fine powder with dry carbonate of soda (NaO, CO_2) and fuse it, for about ten minutes, on a platinum wire before the blowpipe; treat the bead with dilute hydrochloric acid, and observe that the insoluble silicic acid has been changed, by the fusion with the alkali, into the soluble modification. If the solution thus obtained is evaporated to dryness, the silicic acid again becomes insoluble.

427. (C) When pure silicic acid is fused with carbonate of soda before the blowpipe, a transparent colorless bead of silicate of soda is formed, while carbonic acid is expelled.



In this experiment a small quantity only of the soda should be used, as it forms an opaque bead when added in excess.

SECTION VI.

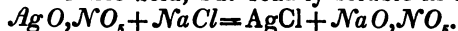
Hydrochloric Acid (HCl).

(Chlorine, in combination with hydrogen or a metal.)

A solution of chloride of sodium (NaCl), or the dilute acid may be used.

428. Chloride of barium gives no precipitate. If, however, it be added to strong hydrochloric acid, the chloride of barium will be precipitated unchanged, as it is insoluble in the strong acid.*

429. (C) Nitrate of silver (AgO, NO_3) throws down white curdy precipitate of chloride of silver (AgCl) which is insoluble in nitric acid, but readily soluble in ammonia

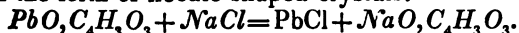


* This circumstance must be remembered when testing hydrochloric acid with chloride of barium, with a view to ascertaining whether it contains traces of sulphuric acid; in which case it is necessary to dilute the acid before testing.

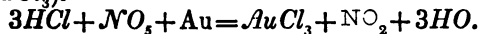
If the ammoniacal solution be neutralized with nitric acid, the chloride is again precipitated.

This precipitate, like most of the salts of silver, becomes purple on exposure to light.

430. (C) *Acetate of lead* ($PbO, C_4H_3O_3 + 3Ag$) gives a white precipitate of chloride of lead ($PbCl$) in tolerably strong solutions of chlorides; if the precipitate be boiled with a little water, it dissolves, and separates again on cooling, in the form of needle shaped crystals.



431. (C) When mixed with *nitric acid*, and warmed, hydrochloric acid dissolves *gold leaf*, forming terchloride of gold ($AuCl_3$).



SECTION VII.

Hydriodic Acid (HI).

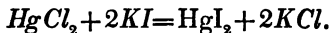
(*Iodine in combination with hydrogen, or a metal.*)

A solution of iodide of potassium (KI) may be used.

432. *Chloride of barium* gives no precipitate with hydriodic acid.

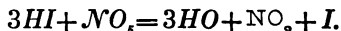
433. (C) *Nitrate of silver* (AgO, NO_3) gives a pale straw-colored precipitate of iodide of silver (AgI), which gradually becomes purple when exposed to the light. It is nearly insoluble in nitric acid, and considerably less soluble in ammonia than the chloride (429).

434. (C) *Perchloride of mercury* ($HgCl_2$) gives a brilliant red precipitate of periodide of mercury (HgI_2), which dissolves in an excess either of the perchloride or of the iodide of potassium.

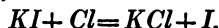


435. (C) *Starch* ($C_{12}H_{10}O_{10}$) forms with iodine, even in highly dilute solutions, a dark purple precipitate of iodide of starch. If the iodine is in a state of combination, as in iodide of potassium or hydriodic acid, it is necessary to liberate it before applying the starch; which is readily done by adding a drop or two of nitric acid (NO_3) or a solution of chlorine: if nitric acid is employed, a portion of its oxy-

gen combines with the hydrogen or metal with which the iodine was in combination, forming water, or a metallic oxide.

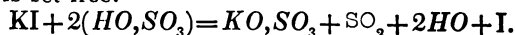


If chlorine be used, it forms with the hydrogen or metal, hydrochloric acid, or a metallic chloride, iodine being liberated in either case.



The starch may be applied either in solution or as a paste; or, what is often more convenient, strips of paper or cotton may be impregnated with the solution, dried, and kept for use.

436. (C) If iodide of potassium, or any other metallic iodide, in the solid state, be heated with a little strong sulphuric acid (HO, SO_3), both compounds are decomposed; sulphurous acid (SO_2) and potash (KO) are formed, and the iodine is set free.



A portion of the latter sublimes in the form of a beautiful violet colored vapor, which condenses in the upper part of the tube, and is highly characteristic.

If the quantity of iodine liberated is so small that the color of the vapor is not perceptible, it may readily be detected by suspending a bit of paper or cotton moistened with a solution of starch, which will instantly be turned purple (435).

437. *Dilute sulphuric acid*, when added to the solution of an iodide, also causes its decomposition, especially if the mixture be boiled, setting free a little iodine, which gives a pale yellowish color to the solution, and causes a purple precipitate with solution of starch.

SECTION VIII.

*Hydrosulphuric Acid (HS).**

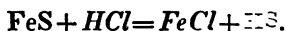
(Sulphur in combination with hydrogen or a metal.)

438. (C) Most of the metallic sulphides are decomposed when treated with hydrochloric acid, in which case hydro-

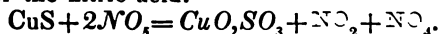
* Called also *sulphuretted hydrogen*.

sulphuric acid (H_2S) is given off, and may be recognized by its disagreeable odor, resembling that of rotten eggs.

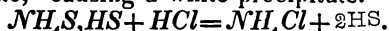
Add a little dilute *hydrochloric* or *sulphuric acid* to a small fragment of sulphide of iron (FeS) in a test-tube; hydrosulphuric acid is immediately evolved; and if a strip of paper, moistened with a solution of acetate of lead, be held over the open end, it will be blackened, owing to the formation of the black sulphide of lead (PbS). The gas may also be passed into a solution of the acetate, in the manner shown in (420), when it will throw down the black sulphide (357).



439. (C) When heated with *nitric acid* (HNO_3), the metallic sulphides are decomposed: the metal is oxidized at the expense of a portion of the nitric acid, orange fumes of nitrous acid and nitric oxide being given off, while the sulphur separates as a whitish powder, which gradually collects into yellowish lumps, and is eventually dissolved, owing to its conversion into sulphuric acid, also at the expense of the nitric acid.



440. (C) The soluble sulphides, or hydrosulphates, are also decomposed by acids, with evolution of hydrosulphuric acid. Add a little *dilute hydrochloric acid* to a drop or two of hydrosulphate of ammonia ($\text{NH}_4\text{S}, \text{HS}$); hydrosulphuric acid is given off, while muriate of ammonia (NH_4Cl) remains in solution, and a little free sulphur is at the same time deposited, which had before been dissolved in the hydrosulphate,* causing a white precipitate.



441. *Chloride of barium* gives no precipitate with hydrosulphuric acid or the hydrosulphates.

442. *Nitrate of silver* (AgNO_3) gives a black precipitate of sulphide of silver (AgS), which is soluble in hot nitric acid.

* When hydrosulphate of ammonia is first prepared, it is colorless, but a portion of the hydrosulphuric acid is gradually decomposed by the affinity of the atmospheric oxygen for its hydrogen, with which it combines to form water, while at the same time the equivalent of sulphur is set free, ($\text{HS} + \text{O} = \text{HO} + \text{S}$); the latter dissolves in the hydrosulphate, giving it a yellow color. It is this sulphur which is precipitated on the addition of an excess of acid to the hydrosulphate.

gen combines with the hydrogen or metal with which the iodine was in combination, forming water, or a metallic oxide.



If chlorine be used, it forms with the hydrogen or metal, hydrochloric acid, or a metallic chloride, iodine being liberated in either case.



The starch may be applied either in solution or as a paste; or, what is often more convenient, strips of paper or cotton may be impregnated with the solution, dried, and kept for use.

386. (C) If iodide of potassium, or any other metallic iodide, in the solid state, be heated with a little strong sulphuric acid (HU_2SO_4), both compounds are decomposed; sulphurous acid (SO_2) and potash (KO) are formed, and the iodine is set free.



A portion of the latter sublimes in the form of a beautiful violet colored vapor, which condenses in the upper part of the tube, and is highly characteristic.

If the quantity of iodine liberated is so small that the color of the vapor is not perceptible, it may readily be detected by suspending a bit of paper or cotton moistened with a solution of starch, which will instantly be turned purple (385).

387. *Phosphoric sulphuric acid*, when added to the solution in the iodide, also causes its decomposition, especially if the mixture be heated, setting free a little iodine, which gives a white milky color to the solution, and causes a purple precipitate with solution of starch.

SECTION VIII.

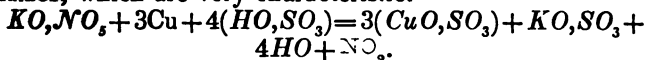
Hydro-sulphuric Acid. 388. *

Sulphur in combination with hydrogen or a metal.

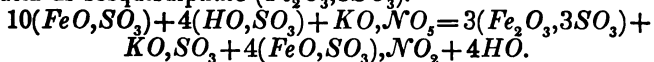
389. (S) Most of the metallic sulphides are decomposed when treated with hydrochloric acid, in which case hydro-

* A small also, uncombined hydrogen.

oxide and nitrous acid are given off, forming orange-colored fumes, which are very characteristic.



449. (C) Add a few drops of strong *sulphuric acid* to a solution of a nitrate in a test-tube, and when the mixture is cold, drop in a small crystal of protosulphate of iron ($FeO,SO_3 + 7Aq$). When nitric acid is present, a brown compound is formed round the crystal, consisting of protoxide of iron (FeO) in combination with nitric oxide (NO_2), while the other three equivalents of oxygen combine with another portion of the protoxide, forming sesquioxide of iron (Fe_2O_3), which is dissolved by the sulphuric acid as sesquisulphate ($Fe_2O_3, 3SO_3$).



If the mixture is heated, the brown compound is decomposed, and the color disappears.

450. (C) If a little *hydrochloric acid* be added to a solution containing nitric acid or a nitrate, the mixture has the property of dissolving gold leaf, owing probably to the liberation of free chlorine, which acts on the metal. The terchloride of gold ($AuCl_3$) thus formed, gives the solution a yellowish color.



451. Strong nitric acid has the property of turning many nitrogenous organic compounds yellow; a fact of which most chemists have unintentionally convinced themselves while experimenting with nitric acid, by the troublesome yellow stains it leaves on the fingers; the cuticle being converted into a compound called xanthoproteic acid. ($2HO, C_{10}H_7N_4O_{12}$).

452. (C) If a nitrate be mixed with a little *sulphuric acid*, and warmed with a drop or two of *sulphate of indigo*, the blue color of the latter disappears, owing to the conversion of the indigo into colorless oxidized compounds.

SECTION X.

Chloric Acid (ClO₃).

Chlorate of potash (KO,ClO₃), both solid and in solution, may be used.

453. *Neither chloride of barium nor nitrate of silver* produce any precipitate in solutions of the chlorates.

454. (C) Heat a small fragment of the chlorate in a test-tube with the flame of a spirit lamp; it is decomposed, and if the heat is continued long enough, the whole of the oxygen is given off. Chloride of potassium (KCl) remains behind.

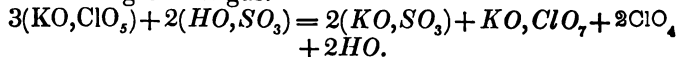


The presence of oxygen may be proved by introducing an ignited match into the tube.

455. (C) Dissolve the residue of chloride of potassium formed in the last experiment, in water, and test the solution with *nitrate of silver* (429). The formation of a chloride after the application of heat is the best proof that the acid is chloric and not nitric.

456. (C) When placed on ignited charcoal, or when heated with organic substances, the chlorates deflagrate even more violently than the nitrates. On this account very small fragments only of the chlorate should be used.

457. (C) Place a small fragment of chlorate of potash (KO,ClO₃) in a test tube, and pour upon it a few drops of strong sulphuric acid (HO,SO₃), *taking especial care not to warm the mixture*, as it is liable to explode with violence when heated. The chlorate is decomposed, sulphate of potash (KO,SO₃) and perchlorate of potash (KO,ClO₄) are formed, together with peroxide of chlorine (ClO₄), which gives the mixture a yellowish color, and escapes in the form of a greenish gas.



458. Repeat experiments 448, 449, and 452, using chlorate of potash instead of the nitrate, and compare the results with those obtained with the latter.

CHAPTER VII.

ORGANIC ACIDS.

459. The organic acids which are enumerated in paragraph 179, may be divided into three classes, according to their behavior with *chloride of calcium* and *perchloride of iron*; thus:

Class I.—Organic acids which are, under certain circumstances, precipitated by a solution of chloride of calcium.

Oxalic ($\text{HO}, \text{C}_2\text{O}_3$). Citric ($3\text{HO}, \text{C}_{12}\text{H}_6\text{O}_{12}$).

Tartaric ($2\text{HO}, \text{C}_8\text{H}_4\text{O}_{10}$). Malic ($2\text{HO}, \text{C}_8\text{H}_4\text{O}_8$).

Class II.—Those which are unaffected by chloride of calcium, but are thrown down by a solution of perchloride of iron.

Succinic ($\text{HO}, \text{C}_4\text{H}_2\text{O}_3$). Benzoic ($\text{HO}, \text{C}_{14}\text{H}_5\text{O}_3$).

Class III.—Those which are not precipitated either by chloride of calcium or by perchloride of iron.

Acetic ($\text{HO}, \text{C}_4\text{H}_3\text{O}_3$). Formic ($\text{HO}, \text{C}_2\text{H}_3\text{O}_3$).

SECTION I.

Oxalic Acid ($\text{HO}, \text{C}_2\text{O}_3$).

460. Oxalic acid is readily soluble in water and in alcohol.

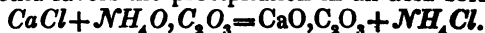
461. When crystallized oxalic acid is heated in a tube, a portion volatilizes unchanged, while a part is decomposed.

462. (C) All the salts of the organic acids are decomposed at a red heat, and when the base is an alkali, or alkaline earth, a carbonate of the base is formed. This decomposition is almost always attended with a deposition of charcoal, and consequent blackening, but in the case of the oxalates scarcely any blackening takes place, the oxalic acid being almost wholly resolved into carbonic acid (CO_2) and carbonic oxide (CO), the latter of which escapes, while the carbonic acid combines with the base.



463. (C) Heat a little oxalate of lime ($\text{CaO}, \text{C}_2\text{O}_3$) to redness for a few moments on platinum foil, and observe that the decomposition takes place almost without blackening. Place the fragment in a test-tube, and moisten it with dilute hydrochloric acid, when the effervescence will show the presence of carbonic acid.

464. (C) *Chloride of calcium* (CaCl), when added to solutions containing oxalic acid, either free or in combination with a base, causes, even in highly dilute solutions, a copious white precipitate of oxalate of lime ($\text{CaO}, \text{C}_2\text{O}_3 + 2\text{Aq}$), which is readily soluble in hydrochloric acid, and slightly so in an excess of oxalic acid, so that the addition of ammonia favors the precipitation in an acid solution.



The presence of ammoniacal salts does not interfere with the formation of this precipitate.

465. (C) A solution of *sulphate* (CaO, SO_3) or any other salt of *lime*, causes the same precipitate ($\text{CaO}, \text{C}_2\text{O}_3 + 2\text{Aq}$), even in very dilute solutions. Lime-water also does the same.

466. *Perchloride of iron* (Fe_2Cl_3) gives no precipitate in solutions of oxalic acid or the oxalates, unless they are concentrated.

467. *Nitrate of silver* (AgO, NO_3) throws down a white precipitate of oxalate of silver ($\text{AgO}, \text{C}_2\text{O}_3$), which is soluble both in nitric acid and ammonia. If the precipitate be dried, and heated on platinum foil, it is dispersed with a slight puff, leaving a residue of metallic silver.

468. (C) When oxalic acid or an alkaline oxalate is warmed with strong *sulphuric acid* (HO, SO_3) it is decomposed into carbonic acid (CO_2) and carbonic oxide (CO), while the basic water or the alkali combines with the sulphuric acid.



The two gases escape with effervescence, and if a taper be applied as they issue from the tube, the carbonic oxide burns with a pale blue flame, combining with an additional equivalent of oxygen from the air, and becoming carbonic acid (41).

SECTION II.

Tartaric Acid ($2\text{HO},\text{C}_8\text{H}_4\text{O}_{10}$).

469. Tartaric acid is soluble both in water and in alcohol.

470. (C) Heat a small crystal of the acid in a tube ; it at first fuses, and is afterwards decomposed with deposition of carbon, and consequent blackening. A peculiar and characteristic odor is at the same time emitted.

471. Fold a small fragment of bitartrate of potash ($\text{KO},\text{HO},\text{C}_8\text{H}_4\text{O}_{10}$) in platinum foil, and heat it to redness before the blowpipe or over a spirit lamp. The tartaric acid is thus decomposed, and carbonate of potash (KO,CO_2) is at the same time formed. Place the fragment in a test-tube, and add a few drops of dilute hydrochloric acid, when it will effervesce, showing the presence of carbonic acid (419).

472. (C) *Chloride of calcium* (CaCl) throws down in neutral solutions containing tartaric acid, a white precipitate of tartrate of lime ($2\text{CaO},\text{C}_8\text{H}_4\text{O}_{10}$), which is soluble in a cold solution of potash ; if the potash solution be heated, however, the tartrate of lime separates as a bulky precipitate, but redissolves as the solution cools.

473. *Lime-water* (CaO) causes in neutral solutions a white precipitate of tartrate of lime ($2\text{CaO},\text{C}_8\text{H}_4\text{O}_{10}$), which is soluble in an excess of acid. The presence of ammoniacal salts prevents the formation of this precipitate, though if the mixture be allowed to stand a few hours, the tartrate of lime gradually crystallizes out.

474. *Sulphate of lime* (CaO,SO_3) gives no precipitate at first, even in neutral solutions of tartrates, but, if allowed to stand, tartrate of lime gradually crystallizes.

475. *Salts of potash* cause the formation of bitartrate of potash ($\text{KO},\text{HO},\text{C}_8\text{H}_4\text{O}_{10}$), which separates from the solution in the form of a granular precipitate, soluble in an excess of alkali, and most of the inorganic acids. If the tartaric acid is present as a neutral tartrate, the bisulphate of potash ($\text{KO},\text{HO},2\text{SO}_3$) should be employed for testing it. In dilute solutions the separation of the precipitate is hastened by agitating the liquid with a glass rod, when

lines of minute crystals will be deposited on the sides of the glass wherever the rod has rubbed against it (184, 186).

476. *Perchloride of iron* (Fe_2Cl_3) gives no precipitate with tartaric acid or the tartrates.

477. (C) *Acetate of lead* ($PbO, C_4H_3O_3 + 3Ag$) throws down a white precipitate of tartrate of lead ($2PbO, C_8H_4O_{10}$) which when washed clean, is readily soluble in ammonia.

478. Tartaric acid and the tartrates, when present in solutions of the persalts of iron, prevent the precipitation of the hydrated peroxide ($Fe_2O_3, 3HO$) when ammonia or potash are added (280). This is owing to the formation of double tartrates of iron and the alkali, which are soluble in water, and are not decomposed by an excess of the latter. Tartaric acid also prevents the precipitation of alumina, protoxide of manganese, and some other oxides, under similar circumstances.

SECTION III.

Citric Acid ($3HO, C_{12}H_6O_{12}$).

479. Citric acid is soluble in water and in alcohol.

480. (C) When heated in a tube, citric acid at first melts, and is subsequently decomposed, emitting pungent fumes, which may be distinguished by their smell from those formed by tartaric acid under similar circumstances. A carbonaceous residue remains in the tube.

481. (C) *Chloride of calcium* ($CaCl$), when added to solutions of neutral citrates, gives a white precipitate of citrate of lime ($3CaO, C_{12}H_6O_{12}$), which is insoluble in potash, but soluble in muriate of ammonia. If the ammoniacal solution be boiled, the citrate of lime reprecipitates. Free citric acid gives no precipitate with this test.

482. (C) *Lime-water* (CaO) fails to produce a precipitate in a cold solution, but if the mixture be boiled, citrate of lime is thrown down, being less soluble in hot water than in cold.

483. *Perchloride of iron* (Fe_2Cl_3) gives no precipitate.

484. *Acetate of lead* ($PbO, C_4H_3O_3 + 3Ag$) throws down a white precipitate of citrate of lead ($3PbO, C_{12}H_6O_{12}$), which

when washed, is only very slightly soluble in ammonia, thus differing from tartaric acid (477).

485. Citric acid and the soluble citrates, when present in solutions containing peroxide of iron, alumina, and some other metallic oxides, prevent their precipitation by ammonia, owing to the formation of soluble double salts.

486. Citric acid when heated with strong *sulphuric acid*, is decomposed; carbonic acid and carbonic oxide are given off with effervescence, and after some time, sulphurous acid (SO_2) is formed, and the mixture becomes dark colored.

SECTION IV.

Malic Acid ($2\text{HO}, \text{C}_8\text{H}_4\text{O}_8$).

487. Malic acid dissolves freely both in water and alcohol.

488. (C) When malic acid is cautiously heated in a tube, it is decomposed into two new acids, maleic acid ($2\text{HO}, \text{C}_8\text{H}_2\text{O}_6$), which being volatile, sublimes and condenses in the upper part of the tube; and fumaric acid ($\text{HO}, \text{C}_4\text{HO}_3$) which remains at the bottom. If the heat is allowed to rise higher than 400° or 500° , further decomposition takes place, and the mass is carbonized.

489. *Chloride of calcium* (CaCl) gives no precipitate, since the malate of lime ($2\text{CaO}, \text{C}_8\text{H}_4\text{O}_8$) is soluble in water: the addition of alcohol, however, immediately causes it to precipitate.

490. *Lime water* (CaO) gives no precipitate with malic acid or the malates.

491. *Perchloride of iron* (Fe_2Cl_3) causes no precipitate, as the malate of iron is soluble in water.

492. (C) *Acetate of lead* ($\text{PbO}, \text{C}_4\text{H}_2\text{O}_3 + 3\text{Ag}$) throws down a white precipitate of malate of lead ($\text{PbO}, \text{HO}, \text{C}_8\text{H}_4\text{O}_8$). If acetate of lead in solution be allowed to stand for a day or two on the precipitate, it is gradually converted into beautiful tufts of silky crystals. If the precipitate be well washed, and, while suspended in water, heated over a lamp, it will be found to melt into a resin-like mass at the temperature of boiling water.

493. Like tartaric and citric acids, malic acid and the

soluble malates prevent the precipitation of peroxide of iron and some other metallic oxides by the alkalies (478, 485).

494. When heated with *oil of vitriol* (HO, SO_3), malic acid is decomposed and carbonized, sulphurous acid (SO_2) being at the same time given off.

SECTION V.

Succinic Acid ($\text{HO}, \text{C}_4\text{H}_2\text{O}_3$).

495. Succinic acid is soluble both in water and alcohol.

496. (C) When the pure acid is heated in a tube, it volatilizes entirely, leaving no carbonaceous residue, and crystallizes in the upper part of the tube. The common acid met with in commerce is seldom pure, and usually leaves a slight residue.

497. *Chloride of calcium* (CaCl) gives no precipitate with succinic acid or the succinates.

498. (C) *Perchloride of iron* (Fe_2Cl_3) throws down a bulky light brown precipitate of persuccinate of iron ($\text{Fe}_2\text{O}_3, 2\text{C}_4\text{H}_2\text{O}_3$) from perfectly neutral solutions containing succinic acid. This precipitate is soluble in acids, and is decomposed by ammonia, which removes the greater part of the acid.

499. *Acetate of lead* ($\text{PbO}, \text{C}_4\text{H}_3\text{O}_3 + 3\text{Ag}$) gives a white precipitate of succinate of lead ($\text{PbO}, \text{C}_4\text{H}_2\text{O}_3$), which is soluble in acid solutions, and is decomposed into a basic salt by ammonia.

500. (C) When treated with a mixture of *chloride of barium, ammonia, and alcohol*, solutions containing succinic acid, give a white precipitate of succinate of baryta ($\text{BaO}, \text{C}_4\text{H}_2\text{O}_3$).

SECTION VI.

Benzoic Acid ($\text{HO}, \text{C}_7\text{H}_5\text{O}_2$).

501. Benzoic acid is scarcely soluble in cold water, but rather more so in hot: it is readily soluble in alcohol.

502. (C) When heated in a tube, it sublimes and condenses in the form of beautiful needle-shaped crystals: the

vapor has a peculiar aromatic odor, and causes an unpleasant sensation in the throat, inducing coughing.

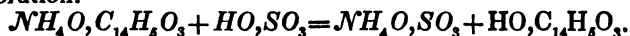
503. *Chloride of calcium* (CaCl) gives no precipitate in solutions of benzoic acid, the benzoate of lime being soluble in water.

504. *Perchloride of iron* (Fe_2Cl_3) gives in neutral solutions, a light yellowish brown precipitate of perbenzoate of iron ($\text{Fe}_2\text{O}_3, 3\text{C}_6\text{H}_5\text{O}_2$) which is soluble in acids, and like the succinate, is decomposed by ammonia.

505. *Acetate of lead* ($\text{PbO}, \text{C}_4\text{H}_3\text{O}_3 + 3\text{Ag}$) throws down a white precipitate of benzoate of lead ($\text{PbO}, \text{C}_6\text{H}_5\text{O}_2$) in solutions of benzoate of potash or of soda, but not in a solution of the free acid, or of benzoate of ammonia.

506. (C) A mixture of *chloride of barium, ammonia, and alcohol*, gives no precipitate with benzoic acid and the benzoates, thus differing from succinic acid (500).

507. (C) When the solution of an alkaline benzoate, as benzoate of ammonia ($\text{HN}_4\text{O}, \text{C}_6\text{H}_5\text{O}_2$), is treated with strong *sulphuric* or *hydrochloric acid*, it is decomposed, and the liberated benzoic acid, being almost insoluble in water, is precipitated in the form of a white crystalline precipitate; while the sulphate or muriate of ammonia remains in solution.



SECTION VII.

Acetic Acid ($\text{HO}, \text{C}_2\text{H}_3\text{O}_2$).

508. Acetic acid is soluble in all proportions in water: it dissolves also in alcohol.

509. (C) When heated, it volatilizes readily, leaving, if pure, no residue; the fumes have an exceedingly pungent odor, resembling that of vinegar, which owes its active properties to the acetic acid which it contains.

510. *Chloride of calcium*, and the other salts of lime, give no precipitate with acetic acid or the acetates.

Perchloride of iron also gives no precipitate, but changes the color of the solution to a deep reddish brown.

511. (C) *Nitrate of silver* (AgO, NO_3) causes in neutral solutions, a white precipitate of acetate of silver (AgO ,

(a) If NO APPARENT ACTION TAKES PLACE, the metal is probably gold or platinum: and if it be found that nothing has dissolved, the absence of all the common, easily oxidizable metals may be inferred.

(b) If the METAL IS ACTED UPON, AND A WHITE PRECIPITATE IS AT THE SAME TIME FORMED, which is found to be insoluble in water, it is probable that antimony or tin is present (391); and if, besides the formation of the white precipitate, some of the metal is dissolved (known by evaporating a drop of the clear liquid on platinum foil), the presence of some other metal, soluble in nitric acid, may be relied on.

(c) If the metal DISSOLVES ENTIRELY, the absence of gold, antimony, and tin may be inferred.

532. *The matter (if any) which proved insoluble in hydrochloric acid (530) is now treated, first with strong nitric acid, and then, if it resists solution, with nitrohydrochloric acid (727), and if necessary boiled. If insoluble in this, it is probably one of the insoluble silicates, sulphates, or chlorides, and will have to be afterwards examined (578, 623).*

SECTION II.

Preliminary examination of liquids.

533. When the substance given for examination is liquid, a drop or two should be evaporated on platinum foil, to ascertain whether or not it contains any fixed matter in solution. If such is the case, a small quantity of the liquid is to be evaporated to dryness in a basin, and the residue examined according to the directions given above for solid substances (524, 526 et seq.). Towards the end of the evaporation, when the residue is nearly dry, and a pellicle of solid matter is formed on the surface, it is very liable to spurt, and project small portions of the substance out of the basin (644); this is best avoided by moderating the heat, and by constantly stirring with a glass rod, so as to prevent the formation of the pellicle.

While the evaporation is going on, the following experiments may be commenced with the solution.

534. *Take its specific gravity* (148).

535. *Test the solution with litmus and turmeric paper*, to ascertain whether it is neutral or otherwise.

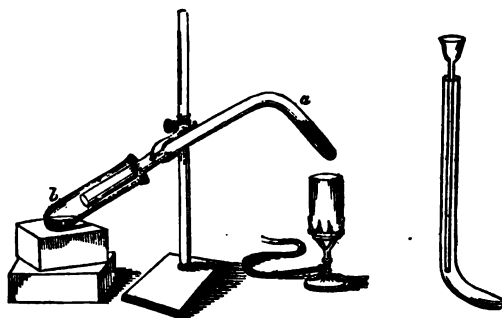
(a) If **NEUTRAL**, the absence of free acids and alkalies, and of acid salts may of course be considered certain. It is probable, also, that the only salts present are those of the alkalies or alkaline earths, as the solutions of most other salts have a feebly acid reaction.

(b) If it has an **ACID REACTION** (known by its reddening blue litmus paper) it is owing to the presence of either an uncombined acid, an acid salt, or a soluble salt of one of the heavy metals, many of which have a feebly acid reaction. To ascertain which of these is present, pour a little of the solution into a test-tube, and stir it with a glass rod, the end of which is moistened with a solution of carbonate of potash ($KO, CO_2 + 2Ag$); if this causes a precipitate, the acid reaction is probably owing to the presence of a metallic salt; while, if the solution remains clear, a free acid or an acid salt is probably the cause.

(c) If the solution has an **ALKALINE REACTION** (known by its turning turmeric paper brown), it is probably owing to the presence of a free alkali or alkaline earth, one of the alkaline carbonates, or an alkaline sulphide. In this case we are enabled to exclude at once all oxides which are insoluble in alkaline solutions; and if alkaline carbonates are present, none of the alkaline earths can exist in solution, since they would be thrown down as insoluble carbonates.

536. If the solvent liquid is supposed from its **TASTE OR SMELL**, to be other than water, it may be necessary to insulate it from the solid matter it contains, for examination. This is best done, if the liquid is volatile, by distillation in a small retort (61), or if the quantity of liquid is minute, the distillation may be effected in two small tubes as shown in the figure, *a* being the retort, and *b* the receiver; the latter may, if necessary, be kept cool by immersion in cold water. The liquid should be poured down a long tube funnel, to avoid soiling the long limb of *a*. The distilled liquid may then be examined as to its taste, smell, specific gravity, boiling point, &c.

Fig. 74.



537. When the substance to be examined is liquid, containing solid matter in suspension, the latter is to be separated by filtration, and the solid and liquid portions examined separately, according to the directions given (524 et seq. and 533 et seq.).

SECTION III.

Actual Analysis.

Introductory remarks.

538. Having learnt from the preliminary experiments just described, the general nature of the substance under examination, together with its degree of solubility, &c., we proceed to the actual analysis by means of liquid tests, with a view to ascertaining the exact constituents of which it is composed.

We will first, for the sake of simplicity, and leaving entirely out of sight all the rarer substances (179), describe the processes to be followed in the analysis of simple salts, which are known to contain only one metallic oxide or base, combined with one acid; as for example, sulphate of potash (KO, SO_3); or a binary compound of a metal with a non-metallic body (or *haloid* salt), such as chloride of calcium (CaCl); and first those which are readily soluble in water. It is usual to determine the base first, and when

that is done, the student may pass on to (556), and commence testing for the acid.

539. When the presence of any metal or acid is indicated by the action of a reagent employed in qualitative analysis, it is always necessary to confirm our supposition by applying other tests, as it is rarely the case that a single test is sufficiently decided in its results to render the presence of a metal absolutely certain. The student, therefore, when he is led to infer from the result of an experiment, that a certain substance is present, should refer to the action of other reagents on the particular metal or acid in question; when he will have no difficulty, by applying two or three of the most characteristic tests to some of the original solution, in proving his supposition to be correct or otherwise.

CHAPTER II.*

QUALITATIVE ANALYSIS OF A SIMPLE SALT, CONTAINING ONE BASE AND ONE ACID, WHICH IS READILY SOLUBLE IN WATER (529).

SECTION I.

Examination for the base of the salt.

540. Having made a tolerably strong solution of the salt, a little of the solution is treated with a drop or two of *dilute hydrochloric acid* (HCl). If this causes a **WHITE PRECIPITATE**, it is probably owing to the presence of either lead, silver, or protoxide of mercury, the chlorides of which, being more or less insoluble, are precipitated as soon as formed. In order to distinguish between them, a portion of the liquid with the precipitate, is supersaturated with *ammonia* (NH_3).

* The student will find in the Appendix a list of salts, &c., which may be taken for practice in qualitative analysis. He may examine a few of each kind with the assistance of the book, until he finds himself tolerably familiar with the processes; after which he may try them without reference to the printed directions.

(a) If this DISSOLVES THE PRECIPITATE, the base is probably oxide of silver (377).

(b) If the PRECIPITATE BECOMES DARK COLORED, the base is probably protoxide of mercury (338).

(c) If the PRECIPITATE REMAINS UNALTERED by the ammonia, the base is probably oxide of lead (362).

In either case, a portion of the original solution should be tried with some of the most characteristic tests for the suspected metal (539).

Hydrosulphuric acid test.

541. If no precipitate is caused by the hydrochloric acid, the acidified portion of the solution is mixed with one of *hydrosulphuric acid* (HS), or the gas may be passed through it (730) until it smells perceptibly. If THIS CAUSES NO CHANGE, the student may pass on to (547), but if A PRECIPITATE IS PRODUCED, the base is thus shown to be one of those in the fourth class (179), since none of the others are precipitated from an acidified solution by hydrosulphuric acid.

542. If THE PRECIPITATE IS BLACK, the base is either oxide of lead, oxide of copper, oxide of bismuth,* or peroxide of mercury. To prove which of these it is, add to separate portions of the original solution in a test tube, the following tests, until one of them is found to indicate the metal present.

(a) Add a little *dilute sulphuric acid* (HO, SO_3). If this causes a WHITE PRECIPITATE, the base is probably oxide of lead, the white precipitate being in that case sulphate of lead (PbO, SO_3) (361). To confirm this, add some of the other tests for lead (356, 363, 364).

(b) If THE SULPHURIC ACID GIVES NO PRECIPITATE, add to another portion a solution of ammonia (NH_3); if this causes at first a LIGHT BLUE PRECIPITATE, which on the addition of ammonia in excess, redissolves, forming a deep rich BLUE SOLUTION, the base is oxide of copper (369). (Confirm 371, 372.)

(c) To another portion of the original solution, add a

* Bismuth is seldom met with in soluble compounds, since most of its salts are insoluble, or only very sparingly soluble, in water.

few drops of a solution of *potash* (KO): if this causes a **YELLOW PRECIPITATE**, the base is peroxide of mercury (351). (Confirm 346, 353, 354.)

(d) If none of these tests succeed, a little of the solution should be *evaporated nearly to dryness with hydrochloric acid*, and then added to a considerable quantity of water in a test tube; if a **WHITE PRECIPITATE** is produced, the base is probably oxide of bismuth (394). (Confirm 395, 397.)

543. If **THE PRECIPITATE CAUSED BY HYDROSULPHURIC ACID IS BROWN**, the base is probably protoxide of tin (381). (Confirm 379, 382, 386.)

544. If **THE PRECIPITATE CAUSED BY HYDROSULPHURIC ACID IS YELLOW**, either the base is peroxide of tin (388), or one of the oxides of arsenic is present (307).^{*} To determine which of these it is, add to a portion of the original solution, a few drops of dilute *ammonia*; if this causes a **WHITE PRECIPITATE**, the base is probably peroxide of tin (390); (Confirm 387, 393;) while if the **SOLUTION REMAINS CLEAR**, the yellow sulphide is probably that of arsenic.[†] (Confirm 303, 312.)

545. If **THE COLOR OF THE PRECIPITATE THROWN DOWN BY HYDROSULPHURIC ACID IS ORANGE**, the base is probably oxide of antimony (329). (Confirm 332, 334.)

546. If **THE PRECIPITATE WITH HYDROSULPHURIC ACID IS WHITE**, the base is probably peroxide of iron, sulphur being in that case precipitated (278). (Confirm 280, 282.)

Hydrosulphate of ammonia test.

547. When hydrosulphuric acid causes no precipitate, it may be inferred that no metal of the fourth class (179) is present, and that the metal contained in the salt belongs consequently to one of the three other classes. Add

^{*} Although both the oxides of arsenic (AsO_3 and AsO_5) have acid properties, they are best included here among the bases, on account of their behavior with hydrosulphuric acid.

[†] When in the examination of a salt, the precipitate with hydrosulphuric acid is found to be owing to the presence of arsenic, we must still seek for the base by further experiments, since both the oxides of arsenic are acids. When the substance is soluble in water, the base in combination with the **arsenious** or **arsenic acid** will probably be found to be one of the **alkalies**, since the **arsenites** and **arsenates** of all the other metallic oxides are **insoluble in water**.

a little *muriate of ammonia* (NH_4Cl)* to a portion of the original solution, and then a few drops of dilute *ammonia*, unless the solution was quite neutral; in which case the addition of ammonia is unnecessary, its use being to prevent the presence of any excess of acid, which might interfere with the action of the hydrosulphate of ammonia (440).

548. *Add now to the neutral or slightly ammoniacal solution, hydrosulphate of ammonia.* If this causes NO PRECIPITATE, none of the metals of the third class can be present, and the student may pass on to (553). If A PRECIPITATE APPEARS, however, the base is thus shown to be one of those included in the third class: viz. alumina, oxide of chromium, oxide of zinc, protoxide of manganese, protoxide of iron, peroxide of iron, oxide of nickel, or oxide of cobalt.

549. If THE PRECIPITATE IS BLACK, the base is either protoxide or peroxide of iron, oxide of nickel, or oxide of cobalt. To distinguish between them, add to a fresh portion of the solution a little caustic *potash*.

(a) If this causes a DULL PALE GREEN PRECIPITATE, which on exposure to the air becomes RUST COLORED,† the base is protoxide of iron (273). (Confirm 276.)

(b) If it throws down a RUST COLORED PRECIPITATE, the base is probably peroxide of iron (281). (Confirm 282.)

(c) If the precipitate caused by potash is PALE GREEN, which does not become brown by exposure to the air, the base is probably oxide of nickel (288). (Confirm 287, 291, 292.)

(d) If the precipitate is LIGHT BLUE, changing to dirty pink when boiled, the base is probably oxide of cobalt (295). (Confirm 296, 299.)

550. If THE PRECIPITATE CAUSED BY HYDROSULPHATE OF AMMONIA IS FLESH-COLORED, becoming brown by exposure

* Muriate of ammonia is here added to prevent the precipitation of any magnesia that may be present (200), which, as it does not belong to the third class, might cause confusion.

† When it is expected that a change of color will be caused by exposing a precipitate to the air, the best way is to pour a little of the precipitate with the solution containing it, on a piece of filtering paper, when it will come more completely in contact with the air than when allowed to remain in the test-tube.

to the air, the base is probably protoxide of manganese (263). (Confirm 264, 267.)

551. If THE PRECIPITATE THROWN DOWN BY THE HYDRO-SULPHATE IS WHITE, the base is either alumina or oxide of zinc. To distinguish between them, add to a fresh portion of the original solution a little *dilute ammonia*.

(a) If this causes a WHITE PRECIPITATE which is READILY SOLUBLE in excess of ammonia, the base is oxide of zinc (255). (Confirm 260, 261.)

(b) If, on the contrary, the white precipitate thrown down by ammonia is INSOLUBLE IN EXCESS, the base is alumina (241). (Confirm 245.)

552. If THE PRECIPITATE CAUSED BY THE HYDROSULPHATE IS GREEN, the base is probably oxide of chromium (247). (Confirm 248, 251, 252.)

Carbonate of soda test.

553. In case neither hydrosulphuric acid nor hydrosulphate of ammonia produces any precipitate, we know that no metal of the third or fourth class can be present, and that the base we are in search of must consequently belong either to the first or second class.

Add carbonate of soda (NaO, CO_2) to a portion of the original solution: if this causes NO PRECIPITATE, the base does not belong to class II., and the student may pass on to (555). If, on the contrary, a WHITE PRECIPITATE IS PRODUCED, the base is one of those included in the second class, viz., magnesia, lime, baryta, or strontia.

554. To determine which of these it is, add to a little of the original solution in a concentrated state, a few drops of *sulphuric acid* or *sulphate of soda*.

(a) If this causes NO PRECIPITATE, even after standing a few minutes, the base is probably magnesia (205). (Confirm 206, 209.)

(b) If, on the contrary, A PRECIPITATE IS PRODUCED, the base is either lime, baryta, or strontia: to distinguish between them, add to another portion of the original solution, a solution of *sulphate of lime*.

(c) If this causes AN IMMEDIATE PRECIPITATE, the base is probably baryta (225).

(d) If THE PRECIPITATE DOES NOT APPEAR AT FIRST, BUT

GRADUALLY SEPARATES after some little time, the base is probably strontia (233). (Confirm 236.)

(e) If NO PRECIPITATE is caused by sulphate of lime, even after standing, and if *oxalate of ammonia* gives a white precipitate in the diluted solution, the base is lime (218). (Confirm 216, 219.)

555. If neither hydrosulphuric acid, hydrosulphate of ammonia, nor carbonate of soda produces any precipitate, the base is one of the first class, viz. potash, soda, or ammonia. To ascertain which of these it is,

(a) Add to a portion of the dry salt, or of the concentrated solution, in a test-tube, a little caustic *potash* (*KO*), and boil: if the *SMELL OF AMMONIA* is perceptible, and if the vapor produces dense white fumes, when a rod moistened with hydrochloric acid is held near the mouth of the tube, the base is ammonia (195). (Confirm 192, 194.)

(b) If it is not ammonia, add a little *bichloride of platinum* to the concentrated solution; if this causes a *YELLOW CRYSTALLINE PRECIPITATE* either immediately or after standing a short time, the base is potash (185). (Confirm 186, 187.)

(c) If NO PRECIPITATE APPEARS, and if the solution from the last experiment, on evaporating spontaneously, *DEPOSITS YELLOW NEEDLE SHAPED CRYSTALS*, which are readily soluble in water, the base is soda (188). (Confirm 189, 190.)

SECTION II.

*Examination for the acid.**

556. Having ascertained the base of the salt under examination, we next proceed to discover the acid with which it is combined; and here we will, as before, for the sake of simplicity, leave out of sight all the rarer ones, and confine ourselves to those inorganic acids which are most commonly met with in analysis, viz.

* After determining the base of a salt which we know to be soluble in water, it is of course unnecessary, in the subsequent examination, to look for any acid that forms with the base an insoluble salt (See Table of Solubilities in the Appendix).

- Sulphuric (HO,SO_3).	Hydrochloric (HCl).
Phosphoric (PO_3).	Hydriodic (HI).
Boracic (BO_3).	Hydrosulphuric (HS).
Carbonic (CO_2).	Nitric (HO,NO_3).
Silicic (SiO_3).	Chloric (HO,ClO_3).

557. A portion of the original solution, which for this purpose should be tolerably concentrated, is first treated with *dilute sulphuric acid*. If NO APPARENT CHANGE takes place, the student may pass on to (558); but if EFFERVESCENCE ENSUES, the acid is probably either carbonic or hydrosulphuric.

(a) If the gas evolved is INODOROUS, the acid is probably carbonic (419). (Confirm 420, 421.)

(b) If the gas has a SMELL RESEMBLING THAT OF ROTTEN EGGS, the acid is hydrosulphuric, or sulphur combined with a metal (438). (Confirm 439, 443.)

(c) If the dilute sulphuric acid gives a PALE YELLOW OR BROWN COLOR to the solution, the acid is probably hydriodic, in which case iodine is set free, and being slightly soluble, colors the liquid (437). (Confirm 434, 435, 436.) (See also 559 b.)

558. If no effect is produced by the dilute sulphuric acid, a portion of the original neutral solution is tested with *chloride of barium* ($BaCl$); if this produces NO PRECIPITATE, the student may pass on to (559); but if a PRECIPITATE APPEARS, the acid is probably either sulphuric, phosphoric, boracic, or silicic,* since baryta forms with each of them an insoluble salt.

(a) To distinguish between them, add a little strong *hydrochloric acid* to the mixture with the precipitate; if the latter DOES NOT DISSOLVE, the acid is probably sulphuric, because the sulphate of baryta is insoluble, while the phosphate, borate, and recently precipitated silicate of baryta, are soluble in hydrochloric acid (403). (Confirm 404, 405.)

If, on the contrary, THE PRECIPITATE DISSOLVES in the

* Arsenious or arsenic acid, if present, would also cause a precipitate with chloride of barium; but its presence will have been already ascertained during the examination for the base of the salt (544).

hydrochloric acid, the acid is either phosphoric, boracic, or silicic.

(b) *Evaporate a little of the original solution to dryness with hydrochloric acid*; treat the residue again with more of the acid; wash the insoluble matter (if any) with water, and examine it before the blowpipe with carbonate of soda; if a **TRANSPARENT COLORLESS BEAD** is obtained in this way, the acid is silicic (427). (Confirm 424.)

(c) If it is not silicic, add a little *nitrate of silver* to a portion of the original solution; if this gives a **PALE YELLOW PRECIPITATE**, the acid is probably phosphoric (410). (Confirm 409, 412.)

(d) If **THE PRECIPITATE THUS PRODUCED IS WHITE**, and soluble in nitric acid and in ammonia, it is probably boracic (416). (Confirm 417, 418.)

559. If chloride of barium causes no precipitate, a portion of the original solution must be treated with *nitrate of silver* (AgO, NO_2): if this causes **NO PRECIPITATE**, pass on to (560), but if **A PRECIPITATE IS PRODUCED** the acid is probably either hydrochloric or hydriodic.

(a) If the **PRECIPITATE IS WHITE AND CURDY**, insoluble in nitric acid, but readily soluble in ammonia, the acid is hydrochloric (429). (Confirm 431.)

(b) If **THE PRECIPITATE HAS A PALE STRAW COLOR**, and is almost insoluble in ammonia, the acid is probably hydriodic (433). (Confirm 435, 436.)

560. If neither chloride of barium nor nitrate of silver give any precipitate, the acid is probably nitric or chloric.

(a) *Warm a little of the concentrated solution with strong sulphuric acid and copper filings*; if **ORANGE FUMES** are given off, the acid is probably nitric (448). (Confirm 449, 450.)

(b) If the acid is not nitric, *test a small quantity of the solution for chloric acid*, in the manner described in (454, 455), and confirm 457.

CHAPTER III.

QUALITATIVE ANALYSIS OF A SIMPLE SALT, CONTAINING ONE BASE AND ONE ACID (OR A SIMPLE METAL), WHICH IS INSOLUBLE OR NEARLY SO IN WATER, BUT SOLUBLE EITHER IN HYDROCHLORIC, NITRIC, OR NITROHYDROCHLORIC ACID (530 ET SEQ.).

SECTION I.

Examination for base.

561. In dissolving a substance in acid for the purpose of analysis, it is advisable to avoid using a large excess of the solvent, since it might afterwards interfere with the action of some of the reagents; when a large excess has inadvertently been used, it is consequently necessary to get rid of most of it by evaporation, taking care of course that sufficient acid is left to retain the substance in solution. Most of the substances which are insoluble in water and soluble in acids, owe this solubility to their conversion into compounds which are soluble in water; as when zinc or marble is dissolved in dilute hydrochloric acid, the metallic chloride which is formed ($ZnCl$, or $CaCl$), is soluble in water, and consequently requires no excess of acid to retain it in solution. In some cases, however, when the acid acts merely as a solvent towards the substance, without causing decomposition, it is necessary to have an excess of acid, to retain it in solution. This is the case with the phosphates of the alkaline earths, and some other salts, which would not dissolve again if the whole of the acid used to dissolve them, were to be expelled.

562. When nitric acid has been employed, either alone or in conjunction with hydrochloric acid, it is advisable to expel it, and convert the nitrates into chlorides by adding an excess of hydrochloric acid, filtering if necessary (as when silver, lead, or mercury are present (540)), evaporating the solution nearly to dryness, and adding water or dilute hydrochloric acid. The reason why it is advisable

to get rid of the nitric acid is, that it oxidizes and decomposes hydrosulphuric acid, which has to be applied as a test, and thus prevents that reagent playing its proper part in the process.

Hydrosulphuric acid test.

563. Dilute the acid solution with three or four times its bulk of water,* and test a portion of it with *hydrosulphuric acid*; if this causes NO PRECIPITATE, pass on to (564); but if A PRECIPITATE IS PRODUCED, refer back to (540 to 546), as this part of the examination is conducted in the same way as when the substance is soluble in water.

Hydrosulphate of ammonia test.

564. If hydrosulphuric acid gives no precipitate, the base cannot belong to the fourth class. A portion of the solution should next be *neutralized with ammonia* if it contains an excess of acid, or if neutral, a little *muriate of ammonia* should be added (547), and subsequently treated with *hydrosulphate of ammonia*.

If this causes NO PRECIPITATE, pass on to (570); but if A PRECIPITATE IS THROWN DOWN, the base is probably one of those belonging to Class III; or else the precipitate may consist of the phosphate of one of the alkaline earths, which, in that case, would have been dissolved by the acid, and reprecipitated unchanged, when the acid was neutralized by the ammonia and hydrosulphate of ammonia.

565. IF THE PRECIPITATE CAUSED BY THE HYDROSULPHATE IS BLACK, the base is probably protoxide or peroxide of iron, oxide of nickel, or oxide of cobalt. To distinguish between them apply the tests mentioned in (549).

566. IF THE PRECIPITATE THROWN DOWN BY THE HYDROSULPHATE IS FLESH-COLORED, becoming brown by exposure to the air, the base is probably protoxide of manganese (263). (Confirm 264, 267.)

567. IF THE PRECIPITATE IS GREEN, the base is probably oxide of chromium (247). (Confirm 248, 251, 252.)

* If a white precipitate is formed on diluting the acid solution, it is probable that either antimony, bismuth, or tin is present (332, 394, 380).

568. IF THE PRECIPITATE IS WHITE, the base is either alumina or oxide of zinc; or else the precipitate consists of the phosphate (or ammoniophosphate) of magnesia, lime, baryta, or strontia (564).*

To a portion of the original solution, add *potash* in excess; if THE PRECIPITATE AT FIRST FORMED REDISSOLVES, the base is either alumina or oxide of zinc, which may be distinguished from each other in the manner described in (551).

569. IF THE PRECIPITATE THROWN DOWN BY POTASH IS INSOLUBLE IN EXCESS, it consists probably of an earthy phosphate, the base being consequently magnesia, lime, baryta, or strontia. In such a case, it is advisable, before proceeding to ascertain which of these is the base present, to separate the phosphoric acid from it. This is done by adding perchloride of iron (Fe_2Cl_6) to the acid solution, and subsequently ammonia in slight excess; when the whole of the phosphoric acid is precipitated as perphosphate of iron ($2Fe_2O_3, 3HO, 3PO_5$), and any excess of perchloride of iron is at the same time precipitated by the ammonia as hydrated peroxide; leaving in solution a chloride of magnesium, calcium, barium, or strontium, together with muriate of ammonia. The solution thus obtained, and filtered from the precipitate of iron, may now be tested with carbonate of soda, and further examined according to the directions given in (554).

Carbonate of soda test.

570. If hydrosulphate of ammonia causes no precipitate, a portion of the original solution is to be tested for the alkaline earths with *carbonate of soda* (553, &c.).

571. With regard to the alkalies, it is hardly necessary to allude to them here, as the compounds which they form with all the acids in our list (with the exception of silicic) are soluble in water. In the case of an insoluble alkaline silicate, it is only necessary to evaporate a little of the acid solution of it to dryness, and treat the residue with

* Some other salts of the alkaline earths, as the oxalates and borates, would, if present, be thrown down when the solution is neutralized, being like the phosphates, soluble only in acid solutions. For the sake of simplicity, however, the consideration of such compounds is here omitted.

water. The silicic acid will then be left insoluble (425), and the aqueous solution of the alkaline chloride may be tested for potash and soda in the manner described in (555).

SECTION II.

Examination for the acid.

572. If the acid is arsenious or arsenic, it will have been detected in the course of the examination for base (563). It is unnecessary to look for chloric acid, since all its salts are soluble in water, and consequently cannot be met with here.

573. A small portion of the substance in the solid state is first treated with *hydrochloric acid*; if this CAUSES EFFERVESCENCE, the acid is probably carbonic (419); (Confirm 420); or if the gas which is given off has the SMELL OF HYDROSULPHURIC ACID, the substance under examination is probably a metallic sulphide (438). (Confirm 439, 444.)

574. If the substance is not acted on by the hydrochloric acid, *treat a little of it with nitric acid*, and if necessary, boil it.

(a) If this CAUSES EFFERVESCENCE, orange fumes of nitrous acid being given off, and sulphur at the same time deposited, the substance is probably a metallic sulphide (439). (Confirm 444.)

(b) If the substance DISSOLVES IN NITRIC ACID WITHOUT EFFERVESCENCE, add *nitrate of silver* to the acid solution; a WHITE CURDY PRECIPITATE, soluble in ammonia, indicates hydrochloric acid, the original substance being in that case a chloride (429). (Confirm 431.)

575. Treat a little of the substance in the solid state with *strong sulphuric acid*, and apply heat.

(a) If this causes the disengagement of VIOLET VAPOUR OF IODINE, the substance under examination is an iodide (436).

(b) Add a little *alcohol* to the acid mixture, which for this experiment should not contain more than a few drops of sulphuric acid, and apply a light to it in a small eva-

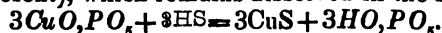
porating dish, placing it in a dark corner, so as to distinguish the color of the flame more readily. If the flame is green at the edges, the acid is probably boracic (418). (Confirm 417.)

(c) Evaporate to dryness a little of the substance after boiling with sulphuric acid, and digest the residue in *hot hydrochloric acid*; if this leaves a white insoluble powder, which when washed, and heated before the blowpipe with carbonate of soda; fuses into a colorless transparent bead, the acid is silicic (425, 427).

(d) Dilute the hydrochloric acid solution formed in (c) with water, and add a solution of *chloride of barium*; if this causes a white precipitate, which is insoluble in nitric acid, the acid is probably sulphuric (403). (Confirm 405, 406.)

576. In testing for phosphoric acid, one of the two following methods may be adopted, according as the base of the salt has been found to belong to the second, third, or fourth class (179).

(a) If the base is one of those in Class IV., the diluted acid solution of the substance, containing only a slight excess of acid, is saturated with *hydrosulphuric acid* (730), which precipitates the metal, and sets free the phosphoric acid (if present), which remains dissolved in the solution.



The liquid should now be filtered from the precipitated sulphide, concentrated by evaporation, supersaturated with *ammonia*, and tested with *sulphate of magnesia*; if a white crystalline precipitate is gradually produced, which is insoluble in muriate of ammonia, the acid is probably phosphoric (409). (Confirm 410, 412.)

(b) If the base has been found to belong to Class II. or III., *perchloride of iron* (Fe_2Cl_6) is added to a portion of the solution of the substance in hydrochloric acid, and subsequently *ammonia* in slight excess; the phosphoric acid, if present, is precipitated in combination with the iron as perphosphate of iron, together with a little hydrated peroxide of iron, if the perchloride has been added in excess. The precipitate thus formed, containing the whole of the phosphoric acid (if sufficient perchloride of iron has been added), is now well washed with distilled water, and

probably a silicate. In this case, the hydrochloric acid solution, together with any portion that may have resisted solution, is evaporated to dryness, and the residue treated with hydrochloric acid, and subsequently with water; if a **WHITE INSOLUBLE POWDER** remains, which fuses with carbonate of soda before the blowpipe into a clear colorless bead, silicic acid is present (425, 427).

The solution obtained in (b), by treating the dry residue with hydrochloric acid and water, contains the base with which the silicic acid was combined; and may be examined according to the directions given in (563 et seq.).

CHAPTER V.

QUALITATIVE ANALYSIS OF A MIXTURE OF TWO OR MORE SALTS, WHICH MAY CONTAIN ALL THE BASES AND ACIDS IN THE LIST (179).

Introductory remarks.

581. Unless we have reason to know that a substance intended for analysis, contains only one base and one acid, it is necessary to assume that it *may* contain any or all of the more common saline compounds. Such an analysis is of course considerably more complicated than that of a single salt, and consequently the necessity of having a well devised scheme of experiments is here even greater than in the former case, when only one base and acid had to be determined.

The method of dealing with such a mixture is, first to separate the whole of the metals of the fourth class (if any are present), by passing hydrosulphuric acid gas through a solution of the substance acidified with hydrochloric acid, and filtering the solution from the precipitate: the precipitate is then dissolved in acid, and tested successively for each of the metals of the fourth class. The filtered solution, containing all the bases but those of the fourth class, is then neutralized, and treated with hydrosulphate of ammonia, which throws down all the metals of the third class

(if any are present); and the precipitate filtered from the solution is dissolved in acid, and tested successively for each metal of the third class. The solution, filtered from the sulphides can now only contain any metals of the first and second class that may be present, which may readily be distinguished by a few simple tests.

582. The student must be careful, when making these experiments, that he adds sufficient of the various reagents, to throw down *the whole* of the metals affected by them, since any traces of the metals belonging to a class supposed to have been entirely removed from the solution, would materially interfere with the indications afforded by the subsequent tests. For example, in the analysis of a mixture of a salt of lead and a salt of lime, if sufficient hydrosulphuric acid were not passed through the solution to separate the whole of the lead, a black precipitate of sulphide of lead would be formed on the addition of hydrosulphate of ammonia to the filtered liquid, indicating the presence of one or more metals of the third class, none of which are really present. On the other hand, the addition of a large excess of any of the reagents is also to be avoided, as being not only useless and wasteful, but in many cases mischievous.

Both these errors may be avoided by adding the reagents in small successive portions; and when the experimenter has reason to think that he has added sufficient, let him filter a few drops of the mixture, and apply to the solution a little more of the reagent: if this produces no further precipitate, he may conclude that enough has been added.

583. When a class of metals has been precipitated by either of the general reagents mentioned in (581), it is always advisable, before proceeding to apply any of the subsequent tests to the filtered solution, to ascertain whether it contains any other fixed bases, as if it does not, the examination of it need not be proceeded with. This is readily known by evaporating a drop or two of the solution on platinum foil, and heating it to redness; when, if no residue is left, it may safely be concluded that all the bases (except ammonia, which must be looked for in a separate portion (602)) have been already separated. In

the course of an analysis, especially of a complicated substance, it is often necessary to have several solutions in hand at the same time; to avoid confusion, each of these should be labelled with a bit of gummed paper, with a letter or mark upon it, referring to a corresponding letter in the note book (7).

584. As one portion of the substance to be analyzed has to be carried through several operations, it is advisable that the quantity operated on should not be very small. When the substance is a solid, twenty or thirty grains may be used; and when in solution, an ounce or two (according to the degree of concentration) will be found a convenient quantity.

CHAPTER VI.

QUALITATIVE ANALYSIS OF A MIXTURE OF SALTS, WHICH MAY CONTAIN ALL THE BASES AND INORGANIC ACIDS IN THE LIST (179), AND WHICH IS READILY SOLUBLE IN WATER (529).*

SECTION I.

Examination for bases.

585. The solution is first rendered slightly acid by the addition of a few drops of *hydrochloric acid*: if this causes NO PRECIPITATE, pass on to (586); but if A WHITE PRECIPITATE IS PRODUCED, it is owing to the presence of silver, lead, or protoxide of mercury. In this case, add hydrochloric acid as long as it causes any precipitate, filter the liquid, and wash the insoluble chloride.

Place a small portion of the moist precipitate in a test-tube, and treat it with *ammonia*.

* It is of course impossible that such a solution can exist, containing *all* the bases and acids in the list, since several of them would form salts which are insoluble in water, as baryta and sulphuric acid, oxide of silver and hydrochloric acid, &c. It is consequently unnecessary, after having determined the bases in a mixture of salts soluble in water, to look for any acids which form with them salts that are insoluble (See Table of Solubilities in the Appendix).

(a) If THE PRECIPITATE DISSOLVES COMPLETELY, it consists wholly of chloride of silver, proving of course the presence of silver in the substance under examination (377). (Confirm 374, 378.)

(b) If THE PRECIPITATE IS BLACKENED, and not wholly dissolved, by the ammonia, it probably contains protochloride of mercury (338). (Confirm 336, 344.)

(c) If it appears to be UNAFFECTED BY THE AMMONIA, it is chloride of lead (362). (Confirm 361, 363, 366.)

(d) If IT DOES NOT WHOLLY DISSOLVE (b and c), pass the ammoniacal mixture through a filter, and neutralize the solution with *nitric acid*: if silver, in addition to lead or mercury, is present, it will be reprecipitated as chloride (377). (Confirm 374, 378.)

Hydrosulphuric acid test.

586. The solution, acidified with hydrochloric acid, and filtered if necessary from the precipitate, is now treated with *hydrosulphuric acid* gas, which must be passed through it until, after removing the delivering tube, and blowing the air from the surface of the solution, the latter smells distinctly of the gas. If NO PRECIPITATE IS PRODUCED, even on boiling the mixture, pass on to (593); but if, on the contrary, A PRECIPITATE FALLS, one or more of the metals of the fourth class are present; if this is the case, the precipitate must be separated from the solution by filtration, and washed with distilled water, until a drop of the washings leaves no fixed residue when evaporated on platinum foil, the filtered solution being carefully reserved for further examination (593).*

587. If THE PRECIPITATE PRODUCED BY HYDROSULPHURIC ACID IS YELLOW, it may be owing to the presence of arsenic (307), or peroxide of tin (388). In this case it is advisable first to dry a little of the precipitate, and test it for arsenic with black flux (303). If arsenic is thus found to be

* In qualitative analysis the first portions only of the washings need be retained (unless we possess only a small quantity of the substance), as the rest would only uselessly dilute our solution; but in quantitative analysis, it is necessary to retain the whole of them, as their rejection would occasion a serious deficiency in the weight of the substance under examination.

bonate of soda, and heat it in a hard glass tube; if mercury is present, METALLIC GLOBULES will condense in the upper part of the tube (336).

592. The nitric acid solution (590) may contain lead, copper, and bismuth.

(a) *Evaporate the solution nearly to dryness, and dilute it with water*; if a WHITE PRECIPITATE is produced, bismuth is probably present (394). (Confirm 395, 397.)

(b) To the solution formed in (a), filtered, if necessary, from the precipitate, add *dilute sulphuric acid*; if this causes a WHITE PRECIPITATE, lead is probably present (361). (Confirm 363, 366.)

(c) To another portion of the clear solution (a) add *ammonia* in slight excess; if this gives a PALE BLUE PRECIPITATE, which readily redissolves in excess of ammonia, forming a BLUE SOLUTION, copper is present (369).

Hydrosulphate of ammonia test.

593. A few drops of the solution filtered from the precipitate thrown down by hydrosulphuric acid, or which failed to produce a precipitate with it (586), are now evaporated on platinum foil, to ascertain whether it contain any other fixed base; and if it is found to leave NO RESIDUE, the examination need not be proceeded with; but if A RESIDUE IS LEFT, a small portion of the solution is neutralized with *ammonia* in a test-tube, and treated with *hydrosulphate of ammonia*. If this gives NO PRECIPITATE, the solution does not contain any of the metals in the third class, and the student may pass on to (596); but if A PRECIPITATE APPEARS, the whole of the liquid is similarly treated, first with *ammonia* and then with the *hydrosulphate*, a little *muriate of ammonia* being also added, unless the solution contained a decided excess of hydrochloric acid, in which case, the muriate would be formed on neutralizing the acid with ammonia.*

When the hydrosulphate has been added as long as it causes any precipitate, the liquid is filtered, and the precipitate well washed, until a drop of the washings, when evaporated on platinum foil and ignited, leaves no fixed

* See note to 547.

The solution is now mixed with a little muriate of ammonia, unless already formed by neutralizing an excess of ammonia or the hydrosulphate with hydrochloric acid; *carbonate of ammonia*, mixed with a little ammonia (741), is added as long as it causes any precipitate, and the solution is boiled. If NO PRECIPITATE is thrown down, the student may pass on to (598), neither lime, baryta, nor strontia being present; but if A PRECIPITATE FALLS, it is owing to the presence of one or more of those bases. In this case the mixture is filtered, and the precipitate (which may contain the carbonates of the alkaline earths just mentioned) is well washed, the filtered solution being retained for subsequent examination (598).

597. The precipitate is dissolved in a small quantity of *hydrochloric acid*; the solution thus formed is neutralized with *ammonia*, and divided into three portions.

(a) Add to the first, *sulphate of soda* as long as it causes any precipitate, and filter. If *oxalate of ammonia* gives with the filtered solution a WHITE PRECIPITATE, lime is present (216). (Confirm 219.)

(b) To the second portion add a solution of *sulphate of lime*; if this causes AN IMMEDIATE WHITE PRECIPITATE, baryta is probably present (225). (Confirm 228.)

(c) The third portion is evaporated to dryness, and a little of the residue heated before the blowpipe; if the FLAME IS TINGED WITH A CARMINE COLOR, strontia is probably present (236). (Confirm 232, 233.)

598. The liquid filtered from the precipitate caused by the carbonate of ammonia, or which failed to give a precipitate with that reagent (596), is now to be examined. If it LEAVES ANY RESIDUE when evaporated on platinum foil, it may contain magnesia, potash, and soda.

When lime, baryta, or strontia have been detected in the mixture, it is always advisable to test a little of the solution filtered from the carbonates, with *oxalate of ammonia* and *sulphate of soda*, in order to see whether the whole of the three earths had been separated by the carbonate of ammonia: if either of the tests shows traces of them, the solution is to be again boiled with a fresh addition of ammonia and carbonate of ammonia, until the whole of them is removed.

599. A little of the ammoniacal solution, moderately concentrated, is now tested with *phosphate of soda*; if this causes a WHITE CRYSTALLINE PRECIPITATE magnesia is present (206). (Confirm 208, 209.)

600. If MAGNESIA IS NOT PRESENT, the ammoniacal solution is evaporated to dryness, and the residue ignited to expel the ammoniacal salts; the residue is then dissolved in as small a quantity as possible of water, and the solution divided into three portions, to be tested according to the directions given in (601).

WHEN MAGNESIA IS PRESENT, it is necessary to separate it from the solution, by some reagent which does not contain soda, since that alkali has still to be sought for in the solution. In such a case, the following is the best method. The remaining portion of the ammoniacal solution is evaporated to dryness, and the residue ignited in a small platinum crucible to expel the ammoniacal salts. The fixed matter is dissolved in a little water, treated with a saturated solution of *caustic baryta*, and allowed to stand some little time, to cause the whole of the magnesia to precipitate (208). The mixture is then filtered; *dilute sulphuric acid* is added in very slight excess to the clear solution, to throw down the whole of the baryta; and the liquid after boiling, is filtered. The filtered solution is evaporated to dryness, to expel the excess of sulphuric acid; and the residue is gently ignited; this is redissolved in the smallest possible quantity of water, and the solution divided into three portions. If NO RESIDUE IS LEFT after the ignition, neither of the fixed alkalies is present.

601. (a) The first portion is tested with *bichloride of platinum*, for potash (185).

(b) The second portion is acidified with *tartaric acid*, also for potash (186).

(c) The third portion is tested with *antimoniate of potash*, for soda (189). (Confirm 188, 190.)

602. As the substance under examination has to be ignited during the analysis, it is of course impossible that ammonia can be detected with the other alkalies in the process now described. A portion of the original solution is therefore to be mixed with an excess of caustic *potash*, and warmed; if ammonia is present, it may be detected

by the **SMELL**, or by holding a rod moistened with *hydrochloric acid*, near the mouth of the test-tube (195).

SECTION II.

Examination for the acids.

603. The original solution of the substance is first examined with litmus and turmeric paper; if it has an acid reaction, a little of it is tested in the manner described in (535 *b*), and if it is found to owe its acid reaction to the presence of free acid, the solution must be carefully neutralized with dilute *potash*; but if it is only a metallic salt which caused it, the solution may be considered neutral. If, on the other hand, the liquid has an alkaline reaction, which may be owing to the presence either of a free alkali, or of alkaline carbonates or hydrosulphates, it must be rendered perfectly neutral by *hydrochloric acid*, and boiled, to expel carbonic or hydrosulphuric acids if either are present.

604. To a small portion of the original solution add *hydrochloric acid* in excess: if this causes **EFFERVESCENCE**, carbonic and hydrosulphuric acids may be present. If no **EFFERVESCENCE** takes place, pass on to (605).

(a) If the **GAS** is **INODOROUS**, or when passed into lime water causes a white precipitate, carbonic acid is present (419, 420).

(b) If the **gas** has a **DISAGREEABLE SMELL**, and when passed into a solution of acetate of lead causes a black or brown precipitate, hydrosulphuric acid (sulphur) is probably present (438). (Confirm 439, 444.)

Nitrate of baryta test.

605. Add to the original solution of the substance, neutralized if necessary (603), *nitrate of baryta* as long as it causes any precipitate. If **NO PRECIPITATE** is formed, pass on to (607). The mixture is filtered, and the precipitate washed, the clear solution being reserved for further examination (607). The precipitate may contain sulphuric,

by nitrate of baryta, or in which that reagent failed to produce a precipitate (605), is now examined. It may contain hydrochloric,* hydriodic, nitric, and chloric acids; and in addition to these, in case the original solution was dilute, or contained ammoniacal salts, traces of boracic, arsenious, and arsenic acids. The solution is treated with *nitrate of silver*: if any PRECIPITATE IS PRODUCED, the mixture is filtered, and the clear solution reserved for subsequent examination (608).

(a) Add an excess of *ammonia* to the precipitate; if IT DOES NOT WHOLLY DISSOLVE, hydriodic acid (iodine) is probably present (433). (Confirm 435, 436.)

(b) The ammoniacal solution formed in (a) is supersaturated with *nitric acid*: if a WHITE CURDY PRECIPITATE is thrown down, hydrochloric acid (chlorine) is probably present (429). (Confirm 430, 431.)

(c) The acid solution formed in (b) may contain traces of arsenious, arsenic, and boracic acids. The first two will, if present, have been already found in the examination for the bases; the latter may be detected in the manner described in (606 b).

608. The solution filtered from the precipitate thrown down by nitrate of silver, or in which that reagent failed to produce a precipitate (607), may contain nitric and chloric acids; but as nitric acid has been added to it in the nitrates of baryta and silver, some of the original solution must be used in this part of the examination.

(b) To a small portion of the original solution, add *sulphuric acid and copper filings*: if ORANGE FUMES are disengaged, nitric acid is probably present (448). (Confirm 449, 450.)

(b) Moisten a portion of the original substance in the dry state, with *strong sulphuric acid*: if a GREENISH GAS is evolved, chloric acid is probably present (457). (Confirm 454, 455, 456.)

* If hydrochloric acid has been used to neutralize the solution (603), it will of course be precipitated here, so that it will be necessary to test a little of the original solution, neutralized with *nitric acid*, to ascertain whether any hydrochloric acid or chlorine is present in it.

CHAPTER VII.

QUALITATIVE ANALYSIS OF A MIXTURE OF TWO OR MORE SALTS, WHICH MAY CONTAIN ALL THE BASES AND INORGANIC ACIDS IN THE LIST (179), AND WHICH IS INSOLUBLE, OR NEARLY SO, IN WATER, BUT READILY SOLUBLE IN HYDROCHLORIC, NITRIC, OR NITROHYDROCHLORIC ACID (530).

SECTION I.

Examination for the bases.

609. When it has been found necessary to use a large excess of acid to dissolve the substance, it is advisable, before beginning the analysis, to expel the greater part of it by evaporation (561).

610. When the substance has been dissolved in hydrochloric acid or nitrohydrochloric acid, it is unnecessary to examine it for silver or protoxide of mercury, because the corresponding chlorides of those metals are insoluble in hydrochloric acid. When the solution has been made in nitric acid, a little *hydrochloric acid* is first added to the solution: if this causes NO PRECIPITATE, pass on to (611); but if A WHITE PRECIPITATE IS PRODUCED, silver, protoxide of mercury, and lead may be present. In this case add *hydrochloric acid* as long as it causes any further precipitate, filter, and examine the precipitate with *ammonia*, as already described (585), the solution being retained for further examination (611).

611. When nitric acid has been used in dissolving the substance, either alone or in conjunction with hydrochloric acid, it is advisable to expel it before proceeding to test the solution with hydrosulphuric acid; because when nitric acid is present in a solution, the hydrosulphuric acid is oxidized by it, and is thus prevented from acting in the usual manner on the metallic oxides present. The solution containing nitric acid should therefore be mixed with an excess of hydrochloric acid, filtered if necessary, and evaporated nearly to dryness. The concentrated solution

is then diluted with water, and if any MILKINESS IS PRODUCED on dilution, owing to the presence of antimony, bismuth, or tin, it may be disregarded, as it will not interfere with the action of the hydrosulphuric acid.

Hydrosulphuric acid test.

612. *Hydrosulphuric acid gas* is now passed through the dilute acid solution, until it is saturated; if this causes NO PRECIPITATE, even when the mixture is boiled, pass on to (614); but if A PRECIPITATE IS PRODUCED, it is owing to the presence of one or more metals of the fourth class. The precipitate is to be separated by filtration, and washed as long as a drop of the washings leaves any fixed residue when evaporated on platinum foil; the clear liquid being retained for subsequent examination (614).

613. The precipitate, which may contain the sulphides of all the metals in the fourth class, after being well washed, is digested with *hydrosulphate of ammonia*, and the portions, both soluble and insoluble in the hydrosulphate, are examined in the manner described in (588 to 592).

As, however, in this case, arsenic may coexist with any of the other bases of the fourth class (such compounds being for the most part soluble in acids), it is necessary to examine the precipitate thrown down by acetic acid from the solution of the sulphides in hydrosulphate of ammonia, FOR ARSENIC, as well as for antimony and tin. This may be easily done by applying the reduction test (303).

Hydrosulphate of ammonia test.

614. The solution filtered from the precipitate thrown down by hydrosulphuric acid, or which failed to produce a precipitate with it (612), is now treated with *ammonia* and *hydrosulphate of ammonia*, and examined according to the directions given in (593 to 595). As, however, a mixture such as we are now considering, which is insoluble in water, may contain the EARTHY PHOSPHATES, those compounds, if present, will be thrown down by the ammonia and hydrosulphate (564), and it is necessary to examine the precipitate for lime, magnesia, baryta, and strontia, in addition to the metals belonging to Class III. These earthy phosphates,

if present, will be thrown down by potash, together with any iron that may be present (594, c): that precipitate may consequently contain peroxide of iron, together with the phosphates of lime, magnesia, baryta, and strontia.

(a) The precipitate (594, c) is dissolved in hydrochloric acid, and to a small portion of the solution thus formed, *ferrocyanide of potassium* is added; if this causes a **BLUE PRECIPITATE**, peroxide of iron is present (282).

(b) To the rest of the solution, *perchloride of iron* is added, and afterwards an excess of *ammonia*; this throws down the whole of the iron as hydrated peroxide, which carries with it in combination, any phosphoric acid that may be present; while the solution contains, in the form of chlorides, the alkaline earths which were previously combined with phosphoric acid (569).

(c) The liquid thus obtained is tested, after filtration, for fixed bases, by evaporating a drop on platinum foil; and if **A RESIDUE IS LEFT**, the solution is examined for lime, baryta, strontia, and magnesia, *carbonate* and *muriate of ammonia* being added, and the precipitate and solution treated in the manner described in (597 to 599).

Carbonate of ammonia test.

615. The solution filtered from the precipitate caused by hydrosulphate of ammonia, or in which that reagent failed to produce any precipitate, is now examined for the alkaline earths and alkalies, in the manner already described in the case of substances which are soluble in water (596 to 602).

SECTION II.

Examination for the acids.

616. A little of the substance under examination is mixed with strong hydrochloric acid; if **EFFERVESCENCE TAKES PLACE**, carbonic and hydrosulphuric acids may be present.

(a) If the gas which is evolved causes a **WHITE PRECIPITATE** when passed into *lime water*, carbonic acid is present (419, 420).

(b) If the gas causes a **BLACK OR BROWN PRECIPITATE** when passed into a solution of *acetate of lead*, hydrosul-

phuric acid (sulphur in a sulphide) is present (438). (Confirm 444.)

617. The solution of the substance in hydrochloric acid is now examined for sulphuric, phosphoric, and silicic acids.

(a) A portion of the hydrochloric acid solution is tested with *chloride of barium*; if this causes a WHITE PRECIPITATE, which is insoluble when warmed with an excess of hydrochloric acid, sulphuric acid is present (403). (Confirm 405, 406.)

(b) A little of the hydrochloric acid solution is evaporated to dryness, and the residue treated with *hydrochloric acid*; if a WHITE INSOLUBLE POWDER IS LEFT, which, when washed, and heated before the blowpipe with carbonate of soda, fuses into a transparent colorless bead, silicic acid is present (425, 427).

(c) Phosphoric acid may be detected in the following manner. To a portion of the hydrochloric solution, *perchloride of iron* is added, and then *ammonia* in slight excess; the precipitate thus produced is well washed on a filter, digested, with the aid of a gentle heat, in *hydro-sulphate of ammonia*, and filtered. If the solution thus obtained gradually throws down, when concentrated, a WHITE CRYSTALLINE PRECIPITATE with *sulphate of magnesia*, phosphoric acid is probably present (409, 413). (Confirm 410, 412.)

618. A portion of the substance is treated with *strong nitric acid*, and, if necessary, warmed.

(a) If ORANGE FUMES ARE EVOLVED, and a pale yellow deposit of sulphur is produced, a metallic sulphide is present (439). (Confirm 444.)

(b) Add to the nitric acid solution a few drops of *nitrate of silver*; if this CAUSES A PRECIPITATE, wash it on a filter, and digest in *ammonia*. If a WHITE CURDY PRECIPITATE is thrown down when the ammoniacal solution is neutralized with *nitric acid*, hydrochloric acid (a metallic chloride) is present (429). (Confirm 430, 431.)

619. Test a little of the substance for boracic acid in the manner described in (606, b).

620. If the substance disengages VIOLET COLORED FUMES, when warmed with *strong sulphuric acid*, iodine (a metallic iodide) is present (436).

621. Place a fragment of the dry substance on ignited charcoal: if this occasions DEFLAGRATION, nitric acid is probably present (447). (Confirm 448, 450.)

622. Chloric acid need not be looked for in compounds which are insoluble in water, since all the chlorates are readily soluble.

CHAPTER VIII.

QUALITATIVE ANALYSIS OF A MIXTURE OF TWO OR MORE SALTS, WHICH MAY CONTAIN ALL THE BASES AND INORGANIC ACIDS IN THE LIST (179), AND WHICH IS INSOLUBLE, OR NEARLY SO, IN WATER AND ACIDS.

623. The compounds most likely to be found in such a mixture, are those enumerated in (578). The best method of rendering such a substance soluble, is to fuse it with *carbonate of soda* (580), either in a platinum or porcelain crucible. If any metals of the fourth class are present, which may generally be ascertained by moistening a small fragment of the substance with *hydrosulphate of ammonia* (579), it is safer to use a porcelain crucible.* When this is done, a little silica and alumina will generally be dissolved from the crucible by the action of the soda, and will appear in the course of the analysis.

624. The fused mass is treated with water, filtered, and the aqueous solution, which contains chiefly the excess of the carbonate of soda used, and some of the acids of the insoluble mixture, must be examined, according to the directions given for the analysis of a mixture soluble in water (585, &c.).

625. The portion of the fused matter which is insoluble in water will generally be found to dissolve, when digested, for a few hours, with the aid of a gentle heat, in *dilute hydrochloric* or *nitric acid*; after which the acid solution

* See note to 580.

be examined, according to the directions given for the analysis of a mixture which is insoluble in water, but soluble in acids (609, &c.).

i. When the insoluble substance has to be examined for silicates, as in the case of many siliceous minerals, it may be rendered soluble by fusion with carbonate of baryta or soda. As, however, the analysis of such substances is attended with difficulty, the details of the process need not be considered.*

* Rose, "Analyse Chimique," tom. i. p. 611; ii. 382; also Parnell's "Elements of Chemical Analysis," p. 403.

PART IV.

QUANTITATIVE ANALYSIS.

Introductory Remarks.

627. In the processes which I have now described, the object of the experimenter has been to ascertain what substances are present in a given salt or mixture of salts, which branch of analysis is called *qualitative*. I will now detail a few processes which have for their object the determination of the quantity of the ingredients of saline compounds: this branch of analysis is called *quantitative*. It is not my intention to enumerate the methods which have been devised for the separation and estimation of all, even of the more common compounds, but merely to give the student a general idea of the subject, by conducting him through a few simple examples of quantitative analysis, referring him, if he wishes for more extended information, to the larger works of Rose, Fresenius, and Thudichum.

628. I will first briefly describe some of the more important operations which have to be performed in the course of quantitative analysis, and the student must bear in mind that he must give his attention to them, the more carefully, as he proceeds, as the loss of a single atom of hydrogen or the neglect of a few small quantities of substance may lead to a very great error in the result.

CHAPTER I.

OPERATIONS IN ANALYSIS.

Pulverization.

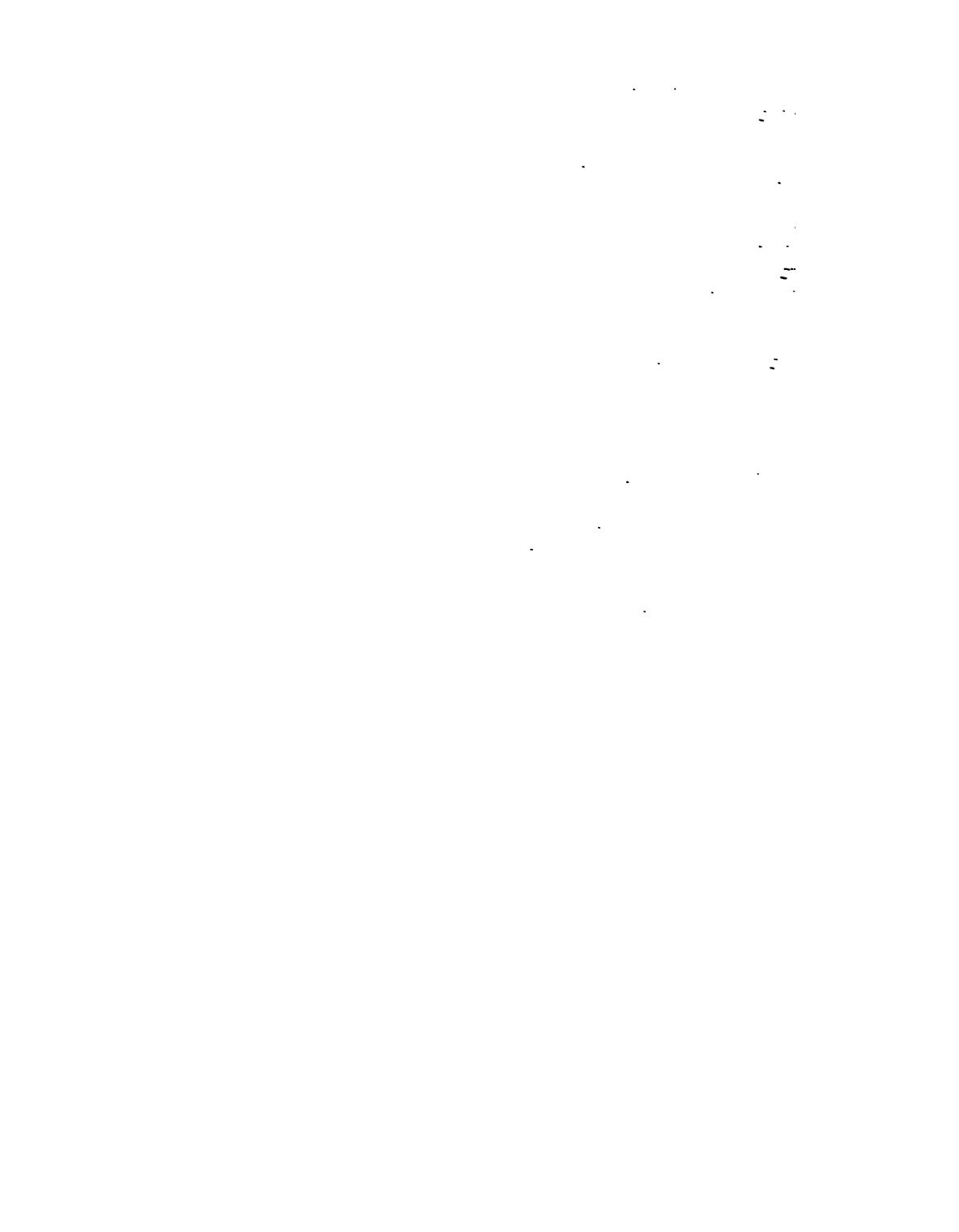
629. Most substances may be reduced to sufficiently fine powder for analysis, by pounding in a common Wedgwood mortar: in some cases, however, it is first necessary to break the substance into small fragments, in one of iron or gum-metal; or in default of this, the substance may be loosely wrapped in strong brown paper, and struck with a hammer. When the substance is difficult of solution, as in the case of some siliceous minerals, it is sometimes necessary to reduce it to an impalpable powder, in a small agate mortar; and on the fineness of this pulverization the success of an analysis often depends.

Drying.

630. Many substances, especially when in the state of powder, absorb moisture from the atmosphere, which, of course, adds to their weight. Before weighing out accurately the quantity of the substance for analysis, it is therefore necessary to deprive it of this hygroscopic moisture. This is generally done by heating it in a small basin, or the water-bath or sand-bath, care being taken that the water does not rise so high as to cause decomposition. The hot water bath shown in the figure is very convenient for drying substances at low temperature: all the apparatus is made hollow and filled with steam.

Fig. 76.





by be
tical
ready
ce to
cir-
oring
veral

twice
(66).
to a
and
glass
oping
ould
le of
en it
d to
ort it
the
using
of the
solid

mixed
of the
into th

Precipitation.

633. When a substance is obtained in solution, various compounds present are in most cases separated for the purpose of estimation, by adding to it some reagent which causes one or more of the ingredients to pass into the solid state; as, when we wish to estimate the quantity of sulphuric acid in any solution, we add a solution of chloride of barium, which, if added in a sufficient quantity, causes the whole of the acid to precipitate in the form of sulphate of baryta (403), which, being insoluble in water, may be washed without loss, and then weighed; the weight of the sulphuric acid which it contains may then be calculated from it (652).

Precipitation is usually effected in upright glass vessels of the forms shown in the

Fig. 79.



When precipitating a substance in quantitative analysis, it is important to add a sufficient amount of the precipitant to throw down the whole of the substance

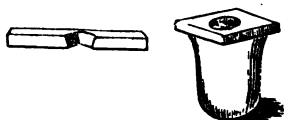
affected by it, as otherwise a deficiency in weight will be occasioned: this is easily ascertained by adding a small quantity of the precipitant to the solution filtered from the precipitate, which will cause a further precipitate if sufficient precipitant has not before been added. When the precipitate is at all soluble, as the bitartrate of potash or ammonio-phosphate of magnesia, it is always advisable to allow the mixture to stand several hours before filtering, in order to ensure the complete separation of the whole of the required salt (184). The whole of the precipitate is then thrown down, and is separated from the solution either by filtration or decantation (643).

Filtration.

634. The process of filtration is that most commonly adopted for separating a precipitate from the solution in which it was formed. The paper best adapted for this purpose is a thin white blotting paper, which should be free from visible holes, and should leave, when burnt,

by capillary attraction, and tend to prevent the passage of the clear solution through them. The filter should never be allowed to reach higher than the top of the funnel, as otherwise the weight of the liquid might cause the paper to give way; and there would also be danger of some of the

Fig. 82.



solution running down the outside of the funnel, after passing through the projecting paper. When the filter is thus prepared, it may be supported either on the ring of a retort stand (for which the form shown at *a* is very convenient), or on a perforated block of wood placed on the glass intended to catch the filtered solution (169), the hole being made to fit the funnel, as shown in the section.

636. The solution to be filtered, should be poured gently down a glass rod, so as to fall on one of the slanting sides of the filter, and not into the apex, as that would endanger the bursting of the paper, and cause splashing. When the whole of the mixture has been poured on the filter, fresh water should not be added for the purpose of washing, until the whole of the solution has passed through; then, by means of a washing-bottle (94), the precipitate left on the filter is well washed; the current of water being applied first towards the upper part of the filter, and directed gradually downwards.

Fig. 83.



When the filter has been thus nearly filled up with water, allow the whole to run through before adding any more, and then repeat the washing, until a drop of the filtered liquid leaves no fixed residue when evaporated and ignited on platinum foil. If the precipitate,

while standing in the filter, cakes together into lumps, these must be broken up, by directing upon them a strong current of water from the washing-bottle, as otherwise the water would not penetrate them, and some of the soluble matter would escape removal.

637. It is sometimes necessary to keep the mixture hot during filtration, to prevent any of the soluble ingredients solidifying: this may be done very conveniently, by placing the funnel in a zinc or copper box of the form shown in the figure, which may be kept full of hot water, and boiling, if necessary, over a lamp.

Fig. 84.



638. The liquid is generally filtered into a beaker glass, and occasionally into flasks or dishes: it is always advisable to cause the stream to run gently down the side of the vessel, and not to fall drop by drop into the centre of the glass, as this would cause splashing and probably some loss. It occasionally happens that some of the precipitate passes through with the filtered solution, as may be seen in the case of freshly precipitated oxalate of lime or sulphate of baryta. When this takes place, it is sometimes necessary to pass it through the filter twice or three times, before it comes through quite clear. This may, however, in most cases be obviated by boiling the mixture before filtering, which causes the finely divided particles of the precipitate to aggregate together. The presence of some saline matters in solution, also, sometimes prevents a precipitate passing through; muriate of ammonia, for example, exerts this property with sulphate of baryta.

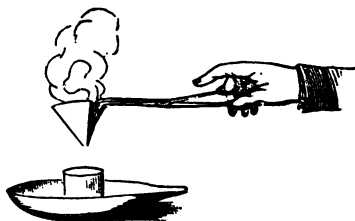
639. When the precipitate on the filter is completely washed, the funnel, with its contents, is placed on a small tripod, or retort stand, on the warm sand-bath, or near a fire, when the precipitate will gradually dry; it may then be separated from the filter, ignited in a small platinum or porcelain crucible (648), (unless decomposable at a high temperature,) and weighed,

640. In cases where the quantity of the precipitate is very small, and where it will not bear a red heat without decomposition, it is often convenient to use two filters for the purpose: they should be folded up together into the proper form, and a hole of about an inch in diameter is then cut with scissors in the centre of the outer one; the inner one is then clipped round the edge, until it weighs exactly the same as the other, when they will, of course, accurately counterpoise each other. They are then again placed one inside the other, the perforated one being outside, after which, the mixture may be filtered through them, washed, and dried. When dry, they are separated and placed in the opposite scales of the balance, when the difference in weight will give the weight of the precipitate, that of the paper being the same in both.

641. The precipitate may also be weighed in a single filter, which should be placed in a covered porcelain crucible of known weight, dried at 212° , and weighed before the mixture is poured in. When the precipitate on the filter has been thoroughly washed, the latter is placed in the crucible, dried as before, and as soon as it is cold, again weighed, when the increase in weight will, of course, be that of the precipitate.

642. It is often necessary, before weighing a precipitate, to burn the filter containing it. After the greater part of the precipitate has been removed, the filter is held with a pair of pliers, and set fire to, over the platinum crucible in which the precipitate is to be ignited, the crucible being placed in a basin, in case any of the ashes should fall over its sides; these are then col-

Fig. 85.



lected and ignited in the crucible (648), together with the portion of the precipitate previously removed from the filter, until the whole of the charcoal derived from the paper is burnt away. In cases of great accuracy, the weight of the paper ashes, ascertained by weighing those derived from a

similar filter, must be deducted from the gross weight; when the paper is good, however, it does not contain more than one to three-thousandths of its weight of inorganic matter, so that this precaution is scarcely necessary in ordinary cases of analysis.

Decantation.

643. When a precipitate is found to subside rapidly to the bottom of the liquid, and when it is known to be very insoluble in water, it may be washed by *decantation*, instead of on a filter, and, in many cases, this is the more expeditious method. The mixture is placed in an upright jar or beaker, which is then filled up with water, and allowed to stand until the precipitate has subsided to the bottom, leaving the superincumbent liquid clear. The latter is then removed with a syphon, or carefully poured off, and the jar again filled up with distilled water, the process being repeated until all the soluble matter has been removed. The wet precipitate is then placed upon a filter, or dried in a dish, and weighed.

Fig. 86.



Evaporation.

644. The process of evaporation is generally most conveniently effected in Berlin porcelain evaporating basins, either on a sand-bath or over a lamp, a loose cover of filtering paper being placed over it, if necessary, to prevent particles of dust falling into the liquid. Care must be taken, in quantitative experiments, that no loss is occasioned by spurting, and, on this account, it is safer not to allow the liquid absolutely to boil. When a saline solution has to be evaporated to dryness, it often becomes covered, when concentrated, with a pellicle of solid matter, which prevents the escape of the steam, which, being thus confined, occasionally causes some of the mixture to be projected violently from the basin. The best way of avoiding

Calculation of results.

652. When the weight of a precipitate has been ascertained, it is necessary to calculate that of the constituent whose weight we wish to learn, and this is readily done according to the well known laws of combination in definite proportions.*

For example, let us suppose that we have to determine the percentage of sulphuric acid (SO_3) in dry sulphate of soda (NaO, SO_3): we dissolve twenty grains of the salt in water, precipitate the sulphuric acid by means of chloride of barium (403), and weigh the sulphate of baryta thus obtained: from this we have to deduce the weight of the sulphuric acid which it contains; and lastly, to calculate from this, the percentage equivalent to it. We find the weight of the sulphate of baryta obtained to be 32.50. Knowing the atomic weight of sulphate of baryta (BaO, SO_3) to be 117, and that of sulphuric acid (SO_3) to be 40, it is easy to calculate how much of the acid is contained in 32.50 grains of the precipitate, thus:—

Atc. wt. of sulph. of baryta.	Atc. wt. of sulph. acid.	Wt. of sulph. of baryta obtained.	Wt. of sulph. acid in 32.50 grs. of sulphate of baryta.
117	40	32.50	$x = 11.11$

Thus we find that twenty grains of the dry sulphate of soda contain 11.11 of sulphuric acid; and we have now only to reduce it to a percentage, to complete the calculation, thus:—

$20 : 11.11 :: 100 : x = 55.55$ sulphuric acid in 100 parts of dry sulphate of soda. Or, as 20 is the fifth part of 100, the same result may be obtained by simply multiplying by 5. $11.11 \times 5 = 55.55$.

CHAPTER II.

EXAMPLES OF QUANTITATIVE ANALYSIS.

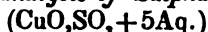
653. In the following examples it is assumed that the nature of the substances has been already ascertained by a

* See Daniell's "Chemical Philosophy," p. 325.

qualitative examination, since it is always necessary, before proceeding to estimate the constituents of a compound, that we should know what those constituents are.

SECTION I.

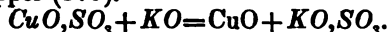
Quantitative analysis of Sulphate of Copper.



Estimate the quantity of oxide of copper (CuO), sulphuric acid (SO_3), and water (HO), in sulphate of copper.

(1.) Estimation of the Oxide of Copper.

654. Dissolve twenty grains of the salt in eight or ten ounces of water, in an evaporating basin, and gently boil the solution. Add to it while boiling, a solution of caustic potash in slight excess, which will throw down the black oxide of copper (370).



The mixture is poured upon a filter (636), and carefully washed with boiling water, until the whole of the soluble matter is removed. The precipitate in the filter is then dried, separated from the filter, ignited, and weighed.

When the precipitate consists, as in this case, of the substance whose weight we wish to ascertain, uncombined with other matter, we have only to reduce the amount thus obtained, to a percentage, thus:—

20 : weight of the precipitate of oxide : : 100 : x = percentage of oxide of copper. Or, in other words, multiply the weight by 5.

(2.) Estimation of the Sulphuric Acid.

655. The acid may be estimated either from the same portion of the substance as was used in determining the oxide (in which case the solution filtered from the precipitated oxide must be concentrated by evaporation (644)), or a fresh portion of the salt may be used. The latter method is in this case the simpler.

656. Dissolve twenty grains of the sulphate in water as before, acidify it with a few drops of nitric acid, and add a solution of chloride of barium (BaCl) as long as it causes

any precipitate. Sulphate of baryta (BaO, SO_3) is thus thrown down (403), and the whole of the sulphuric acid is in this way removed from the solution. As the mixture in its present state would not filter well (638), it is advisable to boil it before filtering, when it will be found that the solution will pass through clear. The precipitate is well washed with hot water on the filter, dried, ignited in a platinum or porcelain crucible, and weighed. Then, knowing the atomic weight of sulphate of baryta to be 117, and that of sulphuric acid (SO_3) to be 40, or, in other words, that every 117 parts of the former contain 40 of the latter, it is easy to calculate the quantity of sulphuric acid contained in the precipitate, thus:—

$$117 : 40 :: \text{weight of the precipitate} : x = \left\{ \begin{array}{l} \text{The sulphuric acid in} \\ 20 \text{ grains of sulphate} \\ \text{of copper;} \end{array} \right\}$$

which number, multiplied by five, will represent the percentage of sulphuric acid in crystallized sulphate of copper.

(3.) *Estimation of the Water.*

657. The water is estimated by heating twenty grains on the sand-bath in a counterpoised crucible, at a temperature of about 400° , until it ceases to lose weight: in this way the water is expelled, and its quantity is shown by the loss of weight, which, when multiplied by five, will give the percentage of water.*

SECTION II.

Quantitative analysis of Chloride of Potassium (KCl).

Estimate the quantity of potassium and chlorine in the chloride.

(1.) *Estimation of the Potassium.*

658. Dissolve twenty grains of the salt in as small a

* When the quantity of water has to be estimated in salts which cannot bear the necessary heat without the volatilization of a portion of their acid, the salt should be intimately mixed with five or six times its weight of protoxide of lead, or some other strong base, before exposure to heat: this combines with, and fixes, any of the acid that may be disengaged from the other base.

quantity of water as possible, in an evaporating basin; add bichloride of platinum to the solution, and evaporate the mixture to dryness on a water-bath (645). Treat the residue with alcohol, to dissolve out the excess of the bichloride, and wash the insoluble double chloride of platinum and potassium (185) with fresh alcohol, on a weighed filter (641). The precipitate is then dried on the filter, at a moderate heat, and weighed.

659. The atomic weight of the double chloride (KCl , $PtCl_2$) being 247, and that of potassium being 40, we deduce the quantity of potassium contained in the twenty grains of the chloride, thus:—

$$247 : 40 :: \left\{ \begin{array}{l} \text{Wt. of double chloride of} \\ \text{platinum and potassium} \end{array} \right\} : \left\{ \begin{array}{l} \text{Wt of potassium con-} \\ \text{tained in 20 grains of} \\ \text{the chloride;} \end{array} \right\}$$

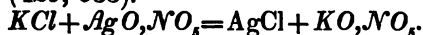
and, lastly, it is reduced to a percentage, thus:—

$$20 : \left\{ \begin{array}{l} \text{Wt. of potassium con-} \\ \text{tained in 20 grains of} \\ \text{the chloride} \end{array} \right\} :: 100 : \text{percentage of potassium :}$$

or the same result may be obtained by multiplying by five.

(2.) *Estimation of the Chlorine.*

660. Twenty grains of the chloride are dissolved in three or four ounces of water, as before; the solution is then heated, acidified with a few drops of nitric acid, and treated with a solution of nitrate of silver, as long as it causes any precipitate (429, 633):



The mixture is then boiled for a few minutes (as otherwise a portion of the precipitate would pass through the pores of the paper (638)), and filtered. The precipitated chloride of silver is thoroughly washed with distilled water on the filter, and dried; it is then removed from the paper, and gently ignited in a counterpoised porcelain crucible, until it fuses into a waxy mass, and weighed.

661. The atomic weight of chloride of silver is 144, and that of chlorine 36, so that we deduce the weight of the chlorine from that of the chloride, thus:—

$$144 : 36 :: \text{wt. of the chloride of silver} : \left\{ \begin{array}{l} \text{Wt. of chlorine contained in 20} \\ \text{grains of chloride of potassium.} \end{array} \right\}$$

Then, for the percentage, multiply by five.

SECTION III.

Quantitative analysis of a mixture of sulphate of copper ($\text{CuO}, \text{SO}_3 + 5\text{Aq}$) and chloride of sodium (NaCl).

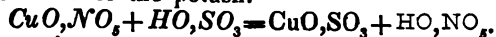
Estimate the quantity of oxide of copper (CuO), sodium, sulphuric acid (SO_3), chlorine, and water in the mixture.

(1.) *Estimation of the Water.*

662. The water is estimated in the manner described in (657).

(2.) *Estimation of the Oxide of Copper.*

663. Dissolve twenty-five grains of the mixture in water, acidify the solution with a few drops of hydrochloric acid, put it into a beaker, and pass through it a stream of hydrosulphuric acid, until it is saturated (730); the whole of the copper is in this way thrown down as sulphide (368). Filter, and wash the precipitate with distilled water, which should contain in solution a little hydrosulphuric acid, as, otherwise a trace of copper is liable to become oxidized and dissolved. The clear solution, together with all but the last washings, is set aside for subsequent examination (664). The washed precipitate of sulphide of copper is now digested with the filter, while moist, in strong nitric acid, until the whole of the precipitate is dissolved, or until nothing remains undissolved but a little sulphur, of a pale yellow color. The acid solution thus obtained, is diluted with water, filtered, if necessary, from the undissolved sulphur, and the fragments of the first filter. The whole of the copper is now contained in the solution as nitrate. This is first to be converted into sulphate, by evaporating the solution to dryness with a slight excess of sulphuric acid, in order to destroy a little organic matter, which is usually derived from the filter, and which would interfere with the action of the potash.



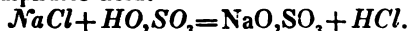
The copper is now to be thrown down as oxide by potash,

dried, and weighed, in the manner already described (654). The percentage is calculated as follows:—

25 : wt. of oxide obtained :: 100 : percentage of oxide of copper in the mixture. Or, as 25 is the fourth part of 100, the same result is arrived at by simply multiplying the weight of the oxide obtained, by 4.

(2.) *Estimation of the Sodium.*

664. The chloride of sodium contained in the solution filtered from the sulphide of copper, is concentrated by evaporation, and then converted into sulphate of soda (NaO, SO_3), by evaporating to dryness with a slight excess of strong sulphuric acid.



The residue is gently ignited in a counterpoised covered crucible, in which a fragment of carbonate of ammonia is suspended by means of a strip of platinum foil, and weighed; the weight of the sodium is thus calculated:—

At. wt. of sulph. soda	At. wt. of sodium	Wt. of sulph. of soda obtained	Sodium in 25 grs. of mixture
72	24	a	x

which, when multiplied by four, gives the percentage of sodium.

(3.) *Estimation of the Sulphuric Acid.*

665. A second portion of twenty-five grains of the mixture is dissolved in water, for the purpose of estimating the sulphuric acid and chlorine.

Add to it first, a solution of nitrate of baryta as long as it causes any precipitate, and boil the mixture for a few minutes, to prevent any of the finely divided sulphate of baryta passing through the filter (638). The precipitate is washed, dried, and weighed, the clear solution being reserved for estimating the chlorine (666); the quantity of sulphuric acid is then calculated in the manner already described (656), twenty-five being substituted for twenty in the calculation.

(4.) *Estimation of the Chlorine.*

666. The solution filtered from the sulphate of baryta

PART V.

CHAPTER I.

EXAMINATION OF CALCULI.*

SECTION I.

Uric (or lithic) acid ($C_{10}N_4H_4O_6$).

689. Heat a small fragment with the blowpipe on platinum foil; it immediately blackens, owing to the charring of the animal matter, emitting at the same time a disagreeable smell, resembling that of burnt feathers, mixed with that of hydrocyanic acid (H, C_2N) which together with carbonate of ammonia and some other compounds, is formed during the decomposition. If the heat is continued, the charred residue is gradually consumed, leaving only a slight trace of ash, which is usually alkaline to test paper, consisting of phosphate or carbonate of soda.

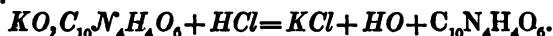
690. Uric acid is insoluble in water, and nearly so in dilute acids.

691. A little of the calculus in powder, is placed in a drop or two of tolerably strong nitric acid, in a watch glass or on a slip of glass; it dissolves with effervescence, carbonic acid and nitrogen being given off, and a mixture of alloxan ($C_8N_2H_4O_{10}$), alloxantine ($C_4H_3N_3O_3$), and some other compounds, remain. This is evaporated nearly to dryness at a gentle heat, when a red residue is left, which *when cold*, and treated with a drop of ammonia, or exposed

* A small fragment about the size of a pin's head, is sufficient for each experiment, and will be found more convenient in practice than a larger quantity.

to ammoniacal fumes, becomes purple, owing to the formation of murexide ($C_{12}N_5H_6O_8$).

692. Uric acid dissolves in a solution of potash, leaving only a few shreds of animal matter, and when the mixture is heated, no smell of ammonia is perceptible, thus differing from the urate of ammonia (696). On neutralizing the alkaline solution with any acid, as hydrochloric, a white precipitate of pure uric acid is thrown down, which, when separated by filtration, may be tested as directed in (689, 691).

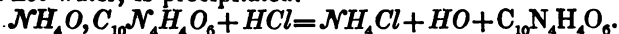


SECTION II.

Urate of Ammonia ($NH_4O, C_{10}N_4H_4O_6$).

693. When heated before the blowpipe, it usually decrepitates, and in other respects behaves like uric acid (689).

694. It dissolves tolerably well in hot water, but being insoluble or nearly so in cold, is deposited again when the solution cools. If a dilute acid (as hydrochloric) be added to a hot solution of urate of ammonia, the latter is decomposed, and uric acid set free, which, being insoluble even in hot water, is precipitated.



695. With nitric acid, urate of ammonia produces the same results as uric acid (691).

696. Urate of ammonia dissolves readily in a warm solution of potash, giving off at the same time ammoniacal fumes (195), by which it may be distinguished from uric acid. The addition of a dilute acid to the hot solution, causes a precipitate of uric acid (692).

SECTION III.

Phosphate of lime ($8CaO, 3PO_5$).

697. Before the blowpipe, it chars, owing to the presence of a little animal matter, and gradually becomes white, as the carbonaceous matter burns away. It is almost infusible, requiring for its fusion so intense and prolonged a heat, that few can succeed in fusing it.

ARTICLE 1

THESE REGLES SONT Etablies
PAR LE COMITE D'ADMINISTRATION

LE 15 JANVIER 1920
A LA REUNION DU 15 JANVIER 1920
A LA REUNION DU 15 JANVIER 1920

LES REGLES SONT Etablies
PAR LE COMITE D'ADMINISTRATION

LES REGLES SONT Etablies
PAR LE COMITE D'ADMINISTRATION
LES REGLES SONT Etablies
PAR LE COMITE D'ADMINISTRATION
LES REGLES SONT Etablies
PAR LE COMITE D'ADMINISTRATION
LES REGLES SONT Etablies
PAR LE COMITE D'ADMINISTRATION

LES REGLES SONT Etablies
PAR LE COMITE D'ADMINISTRATION
LES REGLES SONT Etablies
PAR LE COMITE D'ADMINISTRATION
LES REGLES SONT Etablies
PAR LE COMITE D'ADMINISTRATION
LES REGLES SONT Etablies
PAR LE COMITE D'ADMINISTRATION

ARTICLE 2

Phosphate of ammonia and magnesium, or *Triple Phosphate*,
 $(NH_4)_2MgP_2O_8 \cdot 12H_2O$.

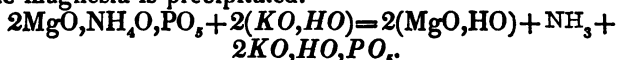
Phosphate of ammonia and magnesium, when heated before the blow-pipe, fuses, and gives off the smell of ammonia, swells up, and fuses to a glassy mass, and ultimately fuses.

Phosphate of ammonia and magnesium is soluble in water, and if boiled, a small quantity is lost.

Phosphate of ammonia and magnesium dissolves readily in dilute hydrochloric, and most other acids, and is again thrown down in the form of a yellow precipitate, when the solution is neutralized with ammonia.

When heated with a solution of potash, it is decom-

posed, the potash combining with the phosphoric acid, and setting free the ammonia and the magnesia. The former volatilizes, and may be detected by its smell (195), while the magnesia is precipitated.



SECTION V.

Fusible calculus, which is a mixture of phosphate of lime ($8\text{CaO}, 3\text{PO}_5$) and the double phosphate of ammonia and magnesia ($2\text{MgO}, \text{NH}_4\text{O}, \text{PO}_5$).

708. This calculus is chiefly characterized by the readiness with which it fuses before the blowpipe, without being consumed, in which respect it differs from all other kinds of calculus. During the ignition, the ammonia and water are expelled, leaving a mixture of the phosphates of lime and magnesia.

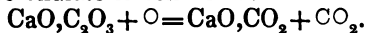
709. If a portion be dissolved in dilute hydrochloric acid, nearly neutralized with ammonia, and treated with oxalate of ammonia, the lime is separated as oxalate (218), while the magnesia remains in solution.

SECTION VI.

Oxalate of lime calculus ($\text{CaO}, \text{C}_2\text{O}_3$).

710. Pounded oxalate of lime dissolves without effervescence* in dilute nitric and hydrochloric acids, and is again thrown down unchanged in the form of a white precipitate, when the acid solution is neutralized with ammonia.

711. When heated before the blowpipe, it blackens, and gives off a disagreeable smell, resembling that of burnt feathers. If the heat be continued a short time, the residue becomes white, and then consists of carbonate of lime, into which the oxalate is converted.



712. Treat the residue formed in the last experiment, with dilute hydrochloric acid: it readily dissolves with

* Occasionally a little carbonate of lime is found mixed with the oxalate, in which case effervescence will of course take place.

effervescence, showing that it has been changed into the carbonate.

713. If the oxalate be kept intensely heated for some time, the carbonate which is at first formed, is reduced to the state of caustic lime (CaO), which may be proved by placing the residue on a piece of moistened turmeric paper, the color of which will be turned brown (122).

SECTION VII.

Biliary calculi, consisting of cholesterin ($C_{36}H_{52}O$) and biliary coloring matter.

714. Heat a small fragment on platinum foil: it will burn with a bright but smoky flame, leaving little or no fixed residue.

715. When coarsely pounded, it dissolves readily in boiling alcohol, and, on cooling, the cholesterin crystallizes out in the form of fine scaly crystals, while the coloring matter remains in solution.

716. It is insoluble in dilute nitric and hydrochloric acids.

717. It is insoluble also in a solution of potash, thus differing from other fatty and oily substances, which cholesterin resembles in many respects.

CHAPTER II.

REAGENTS.

718. The following is a list of the reagents, &c., usually employed in testing and analysis:—

Sulphuric acid, strong and dilute.

Hydrochloric acid.

Nitric acid.

Nitrohydrochloric acid (aqua regia).

Oxalic acid.

Acetic acid.

Tartaric acid.

Hydrosulphuric acid (sulphuretted hydrogen).
Ammonia.
Hydrosulphate of ammonia.
Carbonate of ammonia.
Oxalate of ammonia.
Phosphate of soda and ammonia (microcosmic salt).
Potash.
Carbonate of potash.
Nitrate of potash.
Iodide of potassium.
Chromate of potash.
Cyanide of potassium.
Ferrocyanide of potassium (yellow prussiate of potash).
Ferridcyanide of potassium (red prussiate of potash).
Antimoniate of potash.
Carbonate of soda.
Phosphate of soda.
Borax.
Lime water.
Sulphate of lime.
Chloride of calcium.
Chloride of barium.
Nitrate of baryta.
Perchloride of iron.
Nitrate of cobalt.
Sulphate of copper.
Ammonio-sulphate of copper.
Acetate of lead.
Subacetate of lead.
Nitrate of silver.
Ammonio-nitrate of silver.
Perchloride of mercury.
Protochloride of tin.
Perchloride of gold.
Bichloride of platinum.
Sulphate of indigo.
Solution of starch.
Black flux.
Distilled water.
Alcohol.
Litmus and turmeric paper.

719. Most of these substances, as they are met with in commerce, being always more or less impure, and, as those even which are sold in the shops as pure reagents, are not unfrequently found, on examination, to be otherwise; it is always necessary, before taking a reagent into use, to ascertain by experiment whether it is of sufficient purity for the purposes for which it is intended. It may be stated as a general rule, that, when a chemical substance is required for use in analysis, it ought to be as nearly pure as possible; while, for many of the other operations of chemistry, the substances which are usually met with in commerce are sufficiently pure. The following brief remarks relative to the more common impurities of reagents, together with their principal uses, will probably be found useful to the student.

Sulphuric acid (HO,SO_3).

720. Sulphuric acid, as found in commerce, is never pure. The most common impurities are sulphate of lead (PbO,SO_3), nitric acid (NO_3), or binoxide of nitrogen (NO_2), and occasionally arsenic, and other saline matters.

(a) If it contains the first, it will become turbid when diluted with four or five times its bulk of water, owing to the sulphate of lead, which is soluble in the strong acid, being insoluble in the dilute.

(b) Nitric acid, or the binoxide of nitrogen, is detected by warming a little of the acid in a test tube with a small crystal of protosulphate of iron (449); or by boiling a small portion tinged with a solution of sulphate of indigo, when, if nitric acid is present, the blue color will disappear (452).

(c) Arsenic may be detected by Marsh's test (313).

(d) Any fixed saline impurity remains as a residue when a few drops of the acid are evaporated on platinum foil.

721. The uses of sulphuric acid are very numerous. Besides being employed extensively in many branches of manufacture, it is used in the laboratory as a powerful decomposing agent; owing to its strong affinity for bases, nearly all saline compounds are decomposed by it, and its solvent powers are also very great. It is often employed for the purpose of decomposing organic matter; also in the pre-

paration of hydrogen, hydrosulphuric acid, and other gases; as a test for certain metals, and for many other purposes.

722. When *dilute* sulphuric acid is required, it is prepared by mixing together one part of the strong acid with four parts of distilled water, always *adding the acid to the water*, which should be kept constantly stirred, and allowing the precipitated sulphate of lead (if any) to subside, after which the clear liquid may be poured off.

Hydrochloric acid (HCl).

723. This acid, in the form met with in commerce, is never pure, usually containing sulphuric acid and chloride of iron, and occasionally free chlorine and traces of arsenic.

(a) Evaporate a drop or two on platinum foil: if pure, no residue is left.

(b) Dilute a portion with four or five times its bulk of distilled water, and add a drop of chloride of barium: if sulphuric acid is present, a white precipitate is produced (403).

(c) Add ammonia in excess: a brown precipitate indicates iron (280).

(d) Boil a little of the acid, tinged with sulphate of indigo: if it contains free chlorine, the blue color is bleached.

(e) Arsenic may be detected by Marsh's test (313).

724. The uses of hydrochloric acid are very numerous, especially in analysis, in which it is of constant value as a solvent for substances which are insoluble in water; most of the metals dissolve readily in it, forming soluble chlorides, and it is occasionally used to precipitate silver and mercury from their solutions.

When *dilute* hydrochloric acid is required, the strong acid may be diluted with about twice its bulk of water.

Nitric acid (HO,NO₃).

725. Nitric acid, as met with in commerce, usually contains sulphuric and hydrochloric acids, and occasionally a little fixed saline matter.

(a) The latter may be detected by evaporating a few drops on platinum foil, when any fixed impurities will be left.

31. To a little of the acid with water, and divide it into two portions.

32. To the first, add chloride of barium: if a white precipitate is produced, sulphuric acid is present (403).

33. To the other add nitrate of silver: a white precipitate soluble in ammonia, indicates hydrochloric acid (42).

34. Nitric acid is used chiefly as a solvent for substances which are insoluble in water, especially some of the metals which it readily oxidizes, and converts into nitrates, nearly all of which are soluble in water. It is, also, frequently employed to raise compounds to a higher state of oxidation, as in converting the protoxide of iron (FeO) into the peroxide Fe_2O_3 .

When *dilute* nitric acid is required, it may be prepared by mixing one part of the strong acid with two parts of distilled water.

Nitrohydrochloric acid (aqua regia).

35. This is always prepared when required, by mixing equal parts of strong nitric and hydrochloric acids, usually in the proportion of one part of nitric to four of hydrochloric. It is distinguished by its intense oxidizing or chlorinizing power, and by its dissolving the most refractory metals, some of which are not dissolved in all other acids, are brought into

Preparation of Sulphuretted hydrogen.

36. This reagent, whether required in the gaseous form

or in solution, is prepared

by the following experiment.

37. Sulphuric acid

and iron filings are

placed in a retort, and

the apparatus is

arranged as in the

figure, and the

acid is poured on

the filings, and the

apparatus is

heated, and the

gas is collected

in a jar of water.

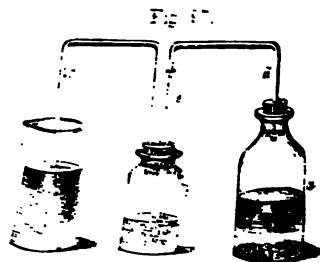
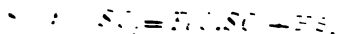


Fig. 17.



(f) Neutralize a small portion with ammonia, and add hydrosulphuric acid or hydrobromic acid of ammonia if lead or any other metallic matter is present except the alkalies and alkaline earths; a precipitate is produced.

735. Acetic acid is chiefly employed as the solvent, and for the purpose of acidifying solutions, in cases where hydrochloric and nitric acids would be injudiciously.

Tartaric acid $\text{C}_4\text{H}_4\text{O}_6$.

736. Tartaric acid sometimes contains a trace of lime and sulphuric acid, but is usually sufficiently pure for analytical purposes. The lime may be detected by neutralizing a portion with ammonia, and adding chloride of ammonia (218); and the sulphuric acid by chloride of barium (403).

737. Tartaric acid is used as a test for potash, with which it forms a sparingly soluble bitartrate 136. Its property of preventing the precipitation of iron and some other metals by the alkalies (478), is occasionally made available in analysis. It should be kept in the solid state, and a solution made when required, as when kept in solution it soon becomes mouldy; for this purpose, the crystallized acid may be dissolved in about three times its weight of water.

Ammonia (NH_3).

738. The liquid ammonia of the shops is generally sufficiently pure for most purposes of analysis; it sometimes, however, contains traces of carbonate, sulphate, and muriate of ammonia, and occasionally chloride of calcium. The carbonate is detected by adding lime water (420); the sulphate by supersaturating with dilute nitric or hydrochloric acid, and testing with chloride of barium (403); the muriate of ammonia may be detected by supersaturating with nitric acid, and adding nitrate of silver (429); and the lime (chloride of calcium) with oxalate of ammonia (218).

Ammonia is used chiefly for the purpose of neutralizing acid solutions, and for precipitating metallic oxides from their solutions, most of which are decomposed by it.

Hydrosulphate of ammonia ($\text{NH}_4\text{S}, \text{HS}$).

739. Hydrosulphate of ammonia is prepared by passing a stream of hydrosulphuric acid gas (728) through a solution of ammonia until it is saturated. To ascertain whether the saturation is complete, a few drops may be tested with sulphate of magnesia; if the ammonia is saturated, this gives no precipitate; but if any free ammonia is left, it throws down the hydrate of magnesia. When first prepared, the solution is almost colorless, but it gradually becomes yellow, owing to partial decomposition, the oxygen of the air combining with the hydrogen, while sulphur is set free, and remains dissolved; when this decomposition has taken place, the addition of an acid causes not only the evolution of hydrosulphuric acid, but also precipitates the dissolved sulphur.

740. Hydrosulphate of ammonia is much used, both in qualitative and quantitative analysis, chiefly for the purpose of precipitating certain metals from their solutions, and for separating the metals of the third class from the alkalies and alkaline earths (593).

Carbonate of ammonia ($2\text{NH}_4\text{O}, 3\text{CO}_2$).

741. The common carbonate of ammonia is a sesquicarbonate, or a compound of the neutral carbonate ($\text{NH}_4\text{O}, \text{CO}_2$) and the bicarbonate ($\text{NH}_4\text{O}, 2\text{CO}_2$). When the neutral carbonate is required, and it is the best suited for most purposes of analysis, it may be prepared in solution by dissolving one part, by weight, of the crystallized sesquicarbonate in three or four parts of water, and adding one part of liquid ammonia (sp. gr. 0.96). It is frequently employed in analysis, to precipitate some of the metals as carbonates: it is also used to neutralize acid solutions, and for other purposes.

742. It is occasionally contaminated with traces of animal oil, and sulphate and muriate of ammonia.

(a) Heat a small fragment on platinum foil: if any fixed saline impurity is present, it will be left after ignition; and if any charring takes place, it indicates the presence of animal matter.

(b) Supersaturate a little of the solution with nitric acid,

and add to one portion a few drops of chloride of barium : a white precipitate insoluble in nitric acid, indicates sulphuric acid (403).

(c) To the other portion of the acid solution, add nitrate of silver : if any muriate of ammonia is present, it will cause a white curdy precipitate (429).

Oxalate of ammonia ($\text{NH}_4\text{O}, \text{C}_2\text{O}_3 + \text{Aq}$).

743. This salt, as met with in the shops, is sufficiently pure for all purposes of analysis. Like oxalic acid, it is employed chiefly for the purpose of precipitating lime from its solutions (218); for this purpose it may be dissolved in about six times its weight of water.

Phosphate of soda and ammonia (microcosmic salt).
($\text{NaO}, \text{NH}_4\text{O}, \text{HO}, \text{PO}_5 + 8\text{Aq}$).

744. This salt occasionally contains traces of chloride of sodium, which may readily be detected by adding a few drops of nitrate of silver to a solution of the salt, acidified with nitric acid, when a curdy white precipitate indicates the presence of the chloride (429).

Microcosmic salt is used almost exclusively in blowpipe experiments : when heated, it is decomposed, the ammonia and water are expelled, and soda, with excess of phosphoric acid, is left.

Potash (KO).

745. On account of its strong affinity for many substances, and its property of readily decomposing others, caustic potash is rarely found free from impurities. Those most commonly met with are organic matter, sulphate and carbonate of potash, chloride of potassium, silicic acid, and alumina.

(a) If organic matter is present, the solution of potash is more or less brown, and, on evaporation, leaves a brown residue.

(b) Sulphuric acid is detected by diluting the potash with water, supersaturating with nitric or hydrochloric acid, and adding chloride of barium, when, if it is present, the white insoluble sulphate is thrown down (403).

(c) If carbonic acid is present, lime water causes a white

Iodide of potassium is employed chiefly as a test for lead, mercury, and occasionally some of the other metals. For use as a reagent, one part of the salt may be dissolved in ten parts of water.

Chromate of potash (K_2CrO_4).

751. This salt occasionally contains traces of sulphate of potash, which is readily detected by precipitating a little of the solution with nitrate of baryta, and adding an excess of nitric acid, which redissolves the chromate of baryta, while any sulphate remains insoluble.

It is employed as a test for several of the metallic oxides, with many of which it forms insoluble salts (chromates) of characteristic colors, as the chromate of lead (363), which is bright yellow. For use as a reagent it may be dissolved in ten times its weight of water.

Cyanide of potassium (KCN).

752. Cyanide of potassium is sometimes used in blow-pipe experiments, and also as a liquid test. It should be colorless, and entirely soluble in water.

Ferrocyanide of potassium ($\text{K}_4\text{FeCy}_6 + 3\text{Aq}$). (*Yellow prussiate of potash*.)

753. This salt, as met with in commerce, is sufficiently pure for the purposes of testing. It is employed as a test for the persalts of iron, with which it forms a deep blue precipitate of sesquiferrocyanide of iron, or prussian blue (282). It gives characteristic precipitates, also, with some other metals. For use as a reagent one part of the salt may be dissolved in fifteen or twenty parts of water.

Ferridcyanide of potassium ($\text{K}_3\text{Fe}_2\text{Cy}_6$). (*Red prussiate of potash*.)

754. It occasionally contains traces of the yellow prussiate, which is easily detected by the solution giving a blue precipitate with perchloride of iron (282). It is used as a test for the protosalts of iron, with which it forms a blue precipitate of ferridcyanide of iron (276), which is similar in appearance to that formed by ferrocyanide of potassium

with the persalts. It may be dissolved in ten or fifteen parts of water.

Antimoniate of potash (KO, SbO_3).

755. This substance seldom or never contains any impurity that can interfere with its action as a test for soda, which is the only use to which it is applied in the laboratory. It must be kept in a well stoppered bottle, and carefully excluded from the air, as the carbonic acid is liable to decompose it, and cause a precipitation of antimonious acid.

Carbonate of soda ($\text{NaO}, \text{CO}_2 + 10\text{Aq}$).

756. The best method of preparing pure carbonate of soda, is to ignite the crystallized bicarbonate ($\text{NaO}, \text{HO}, 2\text{CO}_2$), when the second equivalent of carbonic acid and the water are expelled, and pure anhydrous carbonate is left. The salt of commerce frequently contains a little sulphate and chloride, which may be detected in the manner already detailed (747 *a* and *b*). The more impure varieties contain also traces of sulphide of sodium, and sulphite and hyposulphite of soda. These may be detected by adding dilute sulphuric acid and passing the evolved gas into a solution of acetate of lead; this should cause a white precipitate of carbonate of lead (422), and not a brown one (438); and no precipitation of sulphur should take place on the addition of the acid.

757. It is employed for the same purposes as carbonate of potash (747); also as a flux for the blowpipe, and for fusing with insoluble silicates, &c. For use as a liquid reagent, one part of the salt may be dissolved in ten parts of water.

Phosphate of soda ($2\text{NaO}, \text{HO}, \text{PO}_5 + 24\text{Aq}$).

758. This salt sometimes contains a little sulphate and chloride. To detect these impurities add to one portion in solution, chloride of barium, and to the other nitrate of silver, and supersaturate both with nitric acid: if the precipitate does not entirely dissolve in either case, a sulphate or chloride is present (403, 429).

It is employed chiefly as a test for magnesia, with which it forms, in the presence of ammoniacal salts, the double

phosphate of magnesia and ammonia (206). For the purposes of testing, it may be dissolved in ten parts of water.

Borax (biboate of soda), ($\text{NaO}, 2\text{BO}_3 + 10\text{Aq}$).

759. Borax occasionally contains traces of sulphate and chloride, which may be detected in the same way as in the phosphate of soda (758). It is employed almost exclusively as a flux in blowpipe experiments, for which purpose it is admirably adapted: the second equivalent of boracic acid which it contains, exerts a strong affinity for bases at a high temperature, and is capable of displacing several acids from their combinations; it also forms many double compounds and mixtures which are readily fusible.

Lime water (CaO in water).

760. This reagent is prepared by digesting hydrate of lime (CaO, HO) in cold distilled water for an hour or two, stirring the mixture occasionally, and, when the undissolved portion of the lime has subsided, pouring off the clear solution, and filtering if necessary. As it is liable to spoil when exposed to the air, owing to the absorption of carbonic acid, it should be kept in a well stoppered bottle.

761. Lime water should be sufficiently strong to turn the yellow color of turmeric instantly and decidedly brown; and, when tested with carbonate of soda, should throw down a copious white precipitate of carbonate of lime (214). It is used as a test for carbonic acid and some of the organic acids; for expelling ammonia from its combinations, and for many other purposes.

Sulphate of lime ($\text{CaO}, \text{SO}_3 + 2\text{Aq}$).

762. Sulphate of lime being very sparingly soluble in water, is always used in the form of a saturated solution, which is prepared by digesting the sulphate in water, stirring it occasionally, and pouring off the clear solution from the undissolved portion. It is used chiefly as a test for some of the organic acids, and for distinguishing baryta from strontia. The solution ought to give an immediate precipitate of sulphate of baryta, when tested with chloride of barium (225).

Chloride of calcium (CaCl).

763. This substance occasionally contains a little free acid, and traces of iron. The first is detected by test paper, and the latter, if present, causes hydrosulphate of ammonia to throw down in the solution a black precipitate, or to impart a greenish tint to the liquid (279). As a reagent, chloride of calcium is employed chiefly in testing for some of the organic acids. It is also of great use in the laboratory as a drying agent, having so strong an affinity for water, that a moist gas passed over it, is rapidly and completely deprived of its water. For this purpose the chloride need not be absolutely pure: it should not be fused, but merely dried, as the unfused is more porous, and consequently offers a larger amount of surface to any gas passed over it.

Chloride of barium (BaCl + 2Aq).

764. Chloride of barium sometimes contains traces of iron and lime. It should not be discolored by hydrosulphate of ammonia (279), and, after being treated with a slight excess of sulphuric acid, and filtered, the clear solution should leave no fixed residue when evaporated on platinum foil; because the whole of the baryta is separated by the sulphuric acid, and any other fixed matter must be some impurity.

It is used chiefly for the purpose of testing for acids (558), especially sulphuric, with which it forms the insoluble sulphate of baryta (403). For use, one part of the salt may be dissolved in ten parts of water.

Nitrate of baryta (BaO,NO₃).

765. Nitrate of baryta is liable to the same impurities as chloride of barium (764), and they may be detected in the same way. It should also be free from any chloride, which may be known by adding nitrate of silver (429). Its uses are the same as those of chloride of barium, for which it is occasionally substituted in cases when the addition of the chloride would interfere with the subsequent stages of an analysis, as when we have to test for chlorides in the same

solution (605). For use, it may be dissolved in ten parts of water.

Perchloride of iron (Fe_2Cl_3).

766. This salt is liable to contain a little free acid, and traces of the protochloride (FeCl). The free acid is detected in the manner described in (535, *b*); and if any protosalt of iron is present, the solution gives a blue color with ferridcyanide of potassium (276). It is used as a test for some of the organic acids, and is also sometimes useful in the determination of phosphoric acid. It may be dissolved in five parts of water.

Nitrate of cobalt ($\text{CoO}, \text{NO}_3 + 6\text{Aq}$).

767. This reagent is used chiefly for the detection of alumina, zinc, magnesia, and some other substances, by means of the blowpipe (124). The solution employed for this purpose, may contain one part of the salt dissolved in ten of water.

Sulphate of copper ($\text{CuO}, \text{SO}_3 + 5\text{Aq}$).

768. This salt is occasionally used as a test for arsenic (311); and for other purposes: it may be dissolved in ten parts of water. The *ammonio-sulphate of copper* ($\text{CuO}, 2\text{NH}_3, \text{HO}, \text{SO}_3$), which is also used in testing for arsenic, is prepared by adding ammonia to the solution of sulphate of copper, until the precipitate at first formed is nearly all redissolved, when the solution is filtered, and kept for use.

Acetate of lead ($\text{PbO}, \text{C}_4\text{H}_3\text{O}_3 + 3\text{Aq}$).

769. Acetate of lead is used as a test for several acids, which form with oxide of lead insoluble salts. For testing, one part of the salt may be dissolved in ten parts of water.

Subacetate of lead ($3\text{PbO}, \text{C}_4\text{H}_3\text{O}_3$).

770. The subacetate is prepared by boiling together equal weights of the neutral acetate (769) and protoxide of lead (PbO) in water, and filtering the solution, which must be kept in a well stoppered bottle, as it is easily decomposed when in contact with the air, owing to the strong affinity of the oxide of lead for carbonic acid. Both this

and the neutral acetate are used in testing for hydrosulphuric acid, and for some of the other acids, especially carbonic.

Nitrate of silver (AgO, NO_3).

771. This reagent is sometimes adulterated with nitrate of potash, and occasionally contains traces of copper and lead. When precipitated by a slight excess of hydrochloric acid, the filtered solution ought to leave no fixed residue when evaporated on platinum foil, as the whole of the silver would be thrown down (377), and any impurity would remain in solution. Copper is detected by adding ammonia in excess to the solution, when it will give the liquid a blue tinge (369). Nitrate of silver is used chiefly as a test for chlorine (chlorides and hydrochloric acid), and also for phosphoric, and some of the other acids. For use as a reagent, one part of the salt may be dissolved in twenty parts of water.

772. The *ammonio-nitrate of silver* ($\text{AgO}, 2\text{NH}_3, \text{NO}_3$), used as a test for arsenic, is prepared by adding ammonia to a solution of the nitrate, until the precipitate at first thrown down is nearly all redissolved, and filtering from the undissolved oxide.

Perchloride of mercury (HgCl_2).

773. This is occasionally employed as a test for hydriodic and some other acids, and also for some kinds of organic matter: for this purpose it may be dissolved in twenty parts of water.

Protochloride of tin (SnCl).

774. Protochloride of tin is prepared by boiling metallic tin in strong hydrochloric acid, care being taken that a portion of the metal remains undissolved, as otherwise a little perchloride might be formed; the solution is then filtered, acidified with a few drops of hydrochloric acid, and diluted with about four times its bulk of water. A few fragments of metallic tin should be kept in the solution, in order to prevent the formation of any perchloride.

775. Protochloride of tin is employed chiefly as a test for gold and mercury, and also as a deoxidizing agent, for

which purpose it is well adapted on account of its strong tendency to combine with oxygen or chlorine.

It occasionally contains traces of lead and iron, which may be detected by adding hydrosulphate of ammonia in excess to the solution, when, if pure, the precipitate is wholly redissolved, but, if either of those metals is present, a black residue is left, since their sulphides are insoluble in the hydrosulphate.

Perchloride of gold (AuCl_3).

776. This reagent is used almost exclusively as a test for the protosalts of tin (386), so that a very small quantity will be found sufficient for the purposes of testing. One part of the salt may be dissolved in thirty parts of water.

Bichloride of platinum (PtCl_2).

777. Bichloride of platinum is employed only as a test for potash, soda, and ammonia: it may be dissolved in about ten parts of alcohol.

Sulphate of indigo.

778. This substance may be prepared in solution, by dissolving a little indigo in strong sulphuric acid, and diluting the acid solution with water, so as to form a pale blue liquid. It is used chiefly as a test for nitric acid and chlorine, by which it is decomposed, and its color discharged.

Solution of starch ($\text{C}_{12}\text{H}_{10}\text{O}_{10}$).

779. This is made by gently boiling starch with water. It is employed as a test for iodine, for which purpose small pieces of thread or paper may be steeped in the solution, dried, and kept for use.

Black flux.

780. Black flux is an intimate mixture of carbonate of potash and finely divided charcoal, and is prepared by deflagrating in an iron spoon or crucible, a mixture of two parts of bitartrate of potash and one of nitre. It is used as a reducing flux in blowpipe experiments.

Distilled water (HO).

781. Pure distilled water is prepared by carefully distilling any of the common kinds of water either in a still or retort, rejecting the first and last portions (62). For many purposes, rain water, when collected at a distance from towns or manufactories, and boiled and filtered, will be found sufficiently pure; but, in analytical experiments, distilled water ought always to be used.

782. Before taking it into use, it should be tested with the following reagents:—

(a) Litmus and turmeric paper, for free acids and alkalis.

(b) Chloride of barium for sulphates (403).

(c) Nitrate of silver for chlorides (429). The mixture shortly becomes dark-colored, especially if organic matter is present.

(d) Oxalate of ammonia for lime (218).

(e) Lime water for carbonic acid (420).

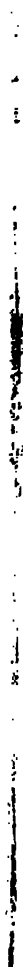
(f) Hydrosulphate of ammonia for any metals of the third or fourth class.

(g) When heated on platinum foil, it should leave no trace of solid residue.

Distilled water is used chiefly as a solvent, and for washing precipitates, besides many other purposes to which it is constantly applied.

Alcohol (C_4H_9O, HO).

783. The alcohol commonly used in chemical experiments should have a specific gravity of about 0.83, except in cases where absolute alcohol is required, when it should be 0.796. When evaporated on platinum foil, it should leave no residue, and should not change the color of litmus paper. It is used chiefly as a solvent, and for the purpose of facilitating the precipitation of substances which are less soluble in it than in water.



APPENDIX.

WEIGHTS AND MEASURES.

Troy or Apothecaries' Weight.

Pound.	Ounces.	Drachms.	Scruples.	Grains.	French Grammes.
1	= 12	= 96	= 288	= 5760	= 372.96
	1	= 8	= 24	= 480	= 31.08
		1	= 3	= 60	= 3.885
			1	= 20	= 1.295
				1	= 0.0647

Avoirdupois Weight.

Pound.	Ounces.	Drachms.	Grains.	French Grammes.
1	= 16	= 256	= 7000	= 453.25
	1	= 16	= 437.5	= 28.328
		1	= 27.343	= 1.77

Imperial Measure.

Gallon.	Pints.	Fluidounces.	Fluidrachms.	Minims.
1	= 8	= 160	= 1280	= 76800
	1	= 20	= 160	= 9600
		1	= 8	= 480
			1	= 60

Weight of Water at 62°, contained in the Imperial Gallon, &c.

					Grains.
1	Imperial Gallon	-	-	=	70,000
1	" Pint	-	-	=	8750
1	" Fluidounce	-	-	=	437.5
1	" Fluidrachm	-	-	=	54.7
1	" Minim	-	-	=	0.91

Cubic Inches contained in the Imperial Gallon, &c.

				Cubic Inches.
1	Imperial Gallon	-	-	277.273
1	" Pint	-	-	34.659
1	" Fluidounce	-	-	1.732
1	" Fluidrachm	-	-	0.2166
1	" Minim	-	-	0.0036

FRENCH WEIGHTS AND MEASURES.

Measures of Length.

	English Inches.					
Millimetre	=	.03937				
Centimetre	=	.39371				
Decimetre	=	3.93710				
Metre	=	39.37100	Mil.	Fur.	Yds.	Feet.
Decametre	=	393.71000	= 0	0	10	2
Hecatometre	=	3937.10000	= 0	0	109	1
Kilometre	=	39371.00000	= 0	4	213	1
Myriometre	=	393710.00000	= 6	1	156	0

Measures of Capacity.

	Cubic Inches.	Gall.	Pints.	F. oz.	F. drms.	Min.
Millimetre	=	.06102	= 0	0	0	16.3
Centilitre	=	.61028	= 0	0	0	42
Decilitre	=	6.10280	= 0	0	3	2
Litre	=	61.02800	= 0	1	15	1
Decalitre	=	610.28000	= 2	1	12	1
Hecatolitre	=	6102.80000	= 22	0	1	4
Kilolitre	=	61028.00000	= 220	0	12	6
Myriolitre	=	610280.00000	= 2200	7	13	4

Measures of Weight.

	English Grains.				
Milligramme	=	.0154			
Centigramme	=	.1544			
Decigramme	=	1.5444			
Gramme	=	15.4440			
Decigramme	=	154.4402	Poun.	Oun.	Dram.
Hecatogramme	=	1544.4023	= 0	0	5.65
Kilogramme	=	15444.0234	= 0	3	8.5
Myriogramme	=	154440.2344	= 2	3	5
			= 22	1	2

Avoirdupois.

TABLE I.

Showing the Quantity of Oil of Vitriol (HO,SO_3) of sp. gr. 1.8485, and of Anhydrous Acid (SO_3), in 100 Parts of Dilute Sulphuric Acid, of different Specific Gravities (Ure).

Liquid Acid.	Sp. Gr.	Dry Acid.	Liquid Acid.	Sp. Gr.	Dry Acid.
100	1.8485	81.54	59	1.4760	48.11
99	1.8475	80.72	58	1.4660	47.29
98	1.8460	79.90	57	1.4560	46.48
97	1.8439	79.09	56	1.4460	45.66
96	1.8410	78.28	55	1.4360	44.85
95	1.8376	77.46	54	1.4265	44.03
94	1.8336	76.65	53	1.4170	43.22
93	1.8290	75.83	52	1.4073	42.40
92	1.8233	75.02	51	1.3977	41.58
91	1.8179	74.20	50	1.3884	40.77
90	1.8115	73.39	49	1.3788	39.95
89	1.8043	72.57	48	1.3697	39.14
88	1.7962	71.75	47	1.3612	38.32
87	1.7870	70.94	46	1.3530	37.51
86	1.7774	70.12	45	1.3440	36.69
85	1.7673	69.31	44	1.3345	35.88
84	1.7570	68.49	43	1.3255	35.06
83	1.7465	67.68	42	1.3165	34.25
82	1.7360	66.86	41	1.3080	33.43
81	1.7245	66.05	40	1.2999	32.61
80	1.7120	65.23	39	1.2913	31.80
79	1.6993	64.42	38	1.2826	30.98
78	1.6870	63.60	37	1.2740	30.17
77	1.6750	62.78	36	1.2654	29.35
76	1.6630	61.97	35	1.2572	28.54
75	1.6520	61.15	34	1.2490	27.72
74	1.6415	60.34	33	1.2409	26.91
73	1.6321	59.52	32	1.2334	26.09
72	1.6204	58.71	31	1.2260	25.28
71	1.6090	57.89	30	1.2184	24.46
70	1.5975	57.08	29	1.2108	23.65
69	1.5868	56.26	28	1.2032	22.83
68	1.5760	55.45	27	1.1956	22.01
67	1.5648	54.63	26	1.1876	21.20
66	1.5503	53.82	25	1.1792	20.38
65	1.5390	53.00	24	1.1706	19.57
64	1.5280	52.18	23	1.1626	18.75
63	1.5170	51.37	22	1.1549	17.94
62	1.5066	50.55	21	1.1480	17.12
61	1.4960	49.74	20	1.1410	16.31
60	1.4860	48.92	19	1.1330	15.49

Liquid Acid.	Sp. Gr.	Dry Acid.	Liquid Acid.	Sp. Gr.	Dry Acid.
18	1.1246	14.68	9	1.0614	7.34
17	1.1165	13.86	8	1.0544	6.52
16	1.1090	13.05	7	1.0477	5.71
15	1.1019	12.23	6	1.0405	4.89
14	1.0953	11.41	5	1.0336	4.08
13	1.0887	10.60	4	1.0268	3.26
12	1.0809	9.78	3	1.0206	2.446
11	1.0743	8.97	2	1.0140	1.63
10	1.0682	8.15	1	1.0074	0.8154

TABLE II.

Showing the Quantity of Real or Anhydrous Nitric Acid (NO_3) in 100 Parts of Liquid Acid, of different Specific Gravities (Ure).

Specific Gravity.	Real acid in 100 parts of the Liquid.	Specific Gravity.	Real acid in 100 parts of the Liquid.	Specific Gravity.	Real acid in 100 parts of the Liquid.
1.5000	79.700	1.4107	58.181	1.2705	36.662
1.4980	78.903	1.4065	57.384	1.2644	35.865
1.4960	78.106	1.4023	56.587	1.2583	35.068
1.4940	77.309	1.3978	55.790	1.2523	34.271
1.4910	76.512	1.3945	54.993	1.2462	33.474
1.4880	75.715	1.3882	54.196	1.2402	32.677
1.4850	74.918	1.3833	53.399	1.2341	31.880
1.4820	74.121	1.3783	52.602	1.2277	31.083
1.4790	73.324	1.3732	51.805	1.2212	30.286
1.4760	72.527	1.3681	51.068	1.2148	29.489
1.4730	71.730	1.3630	50.211	1.2084	28.692
1.4700	70.933	1.3579	49.414	1.2019	27.895
1.4670	70.136	1.3529	48.617	1.1958	27.098
1.4640	69.339	1.3477	47.820	1.1895	26.301
1.4600	68.542	1.3427	47.023	1.1833	25.504
1.4570	67.745	1.3376	46.226	1.1770	24.707
1.4530	66.948	1.3323	45.429	1.1709	23.910
1.4500	66.155	1.3270	44.632	1.1648	23.113
1.4460	65.354	1.3216	43.835	1.1587	22.316
1.4424	64.557	1.3163	43.038	1.1526	21.519
1.4385	63.760	1.3110	42.241	1.1465	20.722
1.4346	62.963	1.3056	41.444	1.1403	19.925
1.4306	62.166	1.3001	40.647	1.1345	19.128
1.4269	61.369	1.2947	39.850	1.1286	18.331
1.4228	60.572	1.2887	39.053	1.1227	17.534
1.4189	59.775	1.2826	38.256	1.1168	16.737
1.4147	58.978	1.2765	37.459	1.1109	15.940

100 parts.		Specific Gravity.		100 parts.		Specific Gravity.	
Alc.	Wat.	At 69°.	At 60°.	Alc.	Wat.	At 69°.	At 60°.
18	82	0.976	0.977	8	92	0.989	0.990
17	83	0.977	0.978	7	93	0.991	0.991
16	84	0.978	0.979	6	94	0.992	0.992
15	85	0.980	0.981	5	95	0.994	
14	86	0.981	0.982	4	96	0.995	
13	87	0.983	0.984	3	97	0.997	
12	88	0.985	0.986	2	98	0.998	
11	89	0.986	0.987	1	99	0.999	
10	90	0.987	0.988	0	100	1.000	
9	91	0.988	0.989				

TABLE VIII.

Showing the Specific Gravities of Mixtures of Ether and Alcohol in different Proportions (Dalton).

Specific Gravity.	Ether.	Alcohol (sp. gr. 830).	Specific Gravity.	Ether.	Alcohol (sp. gr. 830).
724	100	0	792	40	60
732	90	10	804	30	70
744	80	20	816	20	80
756	70	30	828	10	90
768	60	40	830	0	100
780	50	50			

TABLE IX.

OF FREEZING MIXTURES.

Freezing Mixtures with Snow or Pounded Ice.

MIXTURES. Parts by Weight.		Thermometer sinks.	Degree of cold produced.
Sea-salt	1	From any Temperature. to — 5° to — 12° to — 18° to — 25°	
Snow	2		
Sea-salt	2		
Muriate of Ammonia	1		
Snow	5		
Sea-salt	10		
Muriate of Ammonia	5		
Nitrate of Potash	5		
Snow	24		
Sea-salt	5		
Nitrate of Ammonia	5		
Snow	12		
Diluted Sulphuric Acid*	2	from + 32° to — 23°	55 degrees.
Snow	3		
Concentrated Hydrochloric Acid	5	from + 32° to — 27°	59
Snow	8		
Concentrated Nitrous Acid	4	from + 32° to — 30°	62
Snow	7		
Chloride of Calcium	5	from + 32° to — 40°	72
Snow	4		
Crystallized Chloride of Cal- cium	3	from + 32° to — 50°	82
Snow	2		
Fused Potash	4	from + 32° to — 51°	83
Snow	2		

* Made of strong acid, diluted with half its weight of snow or distilled water.

Freezing Mixtures without Snow.

MIXTURES. Parts by Weight.		Temperature falls.	Degree of cold produced.
Muriate of Ammonia -	5	from $+ 50^{\circ}$ to $- 10^{\circ}$	40 degrees.
Nitrate of Potash -	5		
Water - - - -	16		
Muriate of Ammonia -	5	from $+ 50^{\circ}$ to $- 4^{\circ}$	46
Nitrate of Potash -	5		
Sulphate of Soda -	8		
Water - - - -	16		
Nitrate of Ammonia -	1	from $+ 50^{\circ}$ to $- 4^{\circ}$	46
Water - - - -	1		
Nitrate of Ammonia -	1	from $+ 50^{\circ}$ to $- 7^{\circ}$	57
Carbonate of Soda -	1		
Water - - - -	1		
Sulphate of Soda -	3	from $+ 50^{\circ}$ to $- 3^{\circ}$	53
Diluted Nitrous Acid* -	2		
Sulphate of Soda -	6	from $+ 50^{\circ}$ to $- 10^{\circ}$	60
Muriate of Ammonia -	4		
Nitrate of Potash -	2		
Diluted Nitrous Acid -	4		
Sulphate of Soda -	6	from $+ 50^{\circ}$ to $- 14^{\circ}$	64
Nitrate of Ammonia -	5		
Diluted Nitrous Acid -	4		
Phosphate of Soda -	9	from $+ 50^{\circ}$ to $- 12^{\circ}$	62
Diluted Nitrous Acid -	4		
Phosphate of Soda -	9	from $+ 12^{\circ}$ to $- 21^{\circ}$	71
Nitrate of Ammonia -	6		
Diluted Nitrous Acid -	4		
Sulphate of Soda -	8	from $+ 50^{\circ}$ to 0°	50
Hydrochloric Acid -	5		
Sulphate of Soda -	5	from $+ 50^{\circ}$ to $+ 3^{\circ}$	47
Diluted Sulphuric Acid†	4		

* Composed of two parts of fuming nitrous acid, and one of water; the mixture being allowed to cool before being used.

† Composed of equal weights of strong acid and water, being allowed to cool before use.

Showing the Solubility of Salts.*

Bases.	Acids.	Sulphuric.	Phosphoric.	Boric.	Carbonic.	Silicic.	Arsenious.	Arsenic.	Hydrochloric.	Hydrofluoric.	Nitric.	Chloric.	Oxalic.	Tartaric.	Citric.	Malic.	Succinic.	Benzole.	Acetic.	Formic.
Potash	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.
Soda	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.
Ammonia	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.
Magnesia	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.
Lime	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.
Baryta	3.	3.	3.	3.	3.	3.	3.	3.	3.	3.	3.	3.	3.	3.	3.	3.	3.	3.	3.	3.
Strontia	3.	3.	3.	3.	3.	3.	3.	3.	3.	3.	3.	3.	3.	3.	3.	3.	3.	3.	3.	3.
Alumina	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.
Ox. Chromium	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.
Ox. Zinc	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.
Ox. Manganese	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.
Protox. Iron	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.
Perox. Iron	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.
Ox. Nickel	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.
Ox. Cobalt	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.
Ox. Antimony	2.	2.	2.	2.	2.	2.	2.	2.	2.	2.	2.	2.	2.	2.	2.	2.	2.	2.	2.	2.
Protox. Mercury	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.
Perox. Mercury	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.
Ox. Lead	3.	3.	3.	3.	3.	3.	3.	3.	3.	3.	3.	3.	3.	3.	3.	3.	3.	3.	3.	3.
Ox. Copper	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.
Ox. Silver	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.
Protox. Tin	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.
Perox. Tin	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.
Ox. Bismuth	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.	1.

* To ascertain the solubility of any salt, find the name of the base in the upright column, and that of the acid in the line at the top; the

TABLE III.

Showing the Action of Reagents on Oxides and Acids. (Alphabetically arranged.)

1. METALLIC BASES. (IN COMBINATION.)

Name of Base.	Symbol	Hydro-sulphuric Acid (Sulphuretted Hydrogen) (H_2S), in an acidified solution.	Hydro-sulphate of Ammonia (NH_4S , H_2S).	Carbonate of Soda (Na_2CO_3).	Carbonate of Ammonia ($2NH_4CO_3$).	Potash (K_2O).	Ammonia (NH_3).	Ferrocyanide of Potassium (K_4FeC_6).	Blowpipe.	Remarks.
Alumina, (see also p. 100.)	Al_2O_3	○	White; insol. in excess.	White; insol. in excess.	White; insol.	White; sol. in excess.	White; insol.	○	Blue with nitrate of cobalt.	These precipitates are insoluble in muriate of ammonia.
Antimony, oxide of, (see also p. 120.)	Sb_2O_3	Orange red.	Orange red; sol. in excess.	White; sparingly soluble.	White; sp. sol.	White; sp. sol. in excess.	White; insol.	White.	With soda in deoxidizing flame, reduced, and gives off white fumes of oxide.	The chloride decomposed by water.
Baryta, (see also p. 96.)	BaO	○	○	White; insol. in excess.	White; insol.	○	○	○	○	Thrown down immediately with sulphate of lime.

[illegible]

(see also p. 126.)				coming dark brown on boiling.	in ex., forming deep blue solution.	dark brown when boiled.	forming rich blue solution.	colored ; insol.	duced. With borax and mic. salt in outer flame, green ; in inner flame red.	by clean iron ; and as the black oxide by zinc.
Glucina.	SiO_2	O	O	White ; sp. sol.	White ; sol. in ex.	White ; sol. in ex.	White ; insol.	O	With nitrate of cobalt, dark gray or black.	Glucina dissolves in cold solution of carb. ammonia, and is thrown down on boiling.
Gold, peroxide of.	AuO_2	Black.	Brown- black ; sol. in excess.	O	Yellow ; insol.	Yellowish- brown.	Yellow ; insol.	O	Reduced.	Thrown down in the form of a brown metallic powder when boiled with pro- tonsulph. iron.
Iridium, sesqui- oxide of.	Ir_2O_3	Slight brown.	Brown ; sol.	Brown- red ; sp. sol.	Bleaches the solu- tion.	Slight brown. The solution becomes first colorless, and subse- quently bluish.	As with potash. On exposure to the air, a slight blue precipitate falls.	Solution slowly disco- lored.	Reduced.	The solutions have a deep brown color.
Iron, protoxide of, (see also p. 105.)	FeO	O	Black.	White, then green, and ulti- mately rust- colored.	As with carbonate of soda.	White becoming green, and on standing, rust- colored.	As with potash ; but becom- ing brown more rapidly.	White, instantly changing to light blue.	With the fluxes in the outer flame, brownish yellow ; in the inner flame, light green.	Deep blue precipitate with ferridcyanide of potassium.

Name of Base.	Sym- bol.	Hydro- sulphuric Acid (HS) in an acidified solution.	Hydro- sulphate of Ammonia (NH_4S , HS).	Carbonate of Soda (Na_2CO_3 , CO_2).	Carbonate of Ammonia ($2NH_4CO_3$, $3CO_2$).	Potash (KO).	Ammonia (NH_3).	Ferro- cyanide of Potassium (K_4FeC_6).	Blowpipe.	Remarks.
Iron, per- oxide of, (see also p. 106.)	Fe_2O_3 .	Yellowish- white precipitate of sulphur.	Black.	Rust colored.	Rust colored.	Rust colored.	Rust colored.	Deep blue.	As the protoxide.	Black with in- fusion of gall- nuts.
Lead, oxide of, (see also p. 124.)	PbO .	Black.	Black.	White; insol.	White; insol.	White; sol.	White; insol. None at first with the acetate.	White.	With soda on charcoal, re- duced; yellow deposit also formed on the charcoal.	Precipitated by so- luble sulphates, and the precipitate blackened by hy- dro-sulphate of ammonia. Bright yellow with chromate of potash and iodide of potassium.
Lithia.	Li_2O .	○	○	Faint white in concen- trated sol.	As carb. soda.	○	○	○	Gives red color to the flame.	Phos. of soda and ammonia gives a white precipitate.
Magnesia, (see also p. 92.)	MgO .	○	○	White; insol.	○	White; insol.	White; insol.	○	Light pink with nitrate of cobalt.	Crystalline pre- cipitate with phosphate of soda and ammonia. The carbonate and hydrate sol. in muriate of ammonia.

Manganese, protoxide of (see also p. 103.)	MnO.	O	Flesh colored.	White ; insol.	White ; insol.	White, becoming brown.	White ; becoming brown.	White.	With soda, a green bead. With borax in outer flame an amethyst bead, which loses its color in the reducing flame.	The presence of ammoniacal salts prevents more or less completely the precipitation of manganese by the alkalies.
Mercury, protoxide of (see also p. 121.)	HgO.	Black.	Black.	Dark gray.	Dark gray.	Black ; insol.	Black ; insol.	White.	Mixed with soda, and heated in a tube, the metal sublimes.	White precipitate with chlorides, blackened by ammonia. Volat'd or decom'd by heat.
Mercury, peroxide of (see also p. 123.)	HgO ₂ .	White, turning to black.	White, turning to black.	Reddish-brown ; insol.	White ; insol.	Yellow ; insol.	White ; insol.	White.	As the protoxide.	Volatilized or decomposed by heat. Beautiful scarlet with iodide of potassium.
Molybdenum, and oxides of.	MoO and MoO ₃ .	Brown-black, slowly formed.	Yellowish-brown ; sol.	Brown ; sol.	Brown ; sol.	Brown-black ; insol.	Brown-black ; insol.	Brown with the binoxide.	With microcosmic salt in outer flame, a green glass.	Most readily distinguished by the blowpipe.
Nickel, oxide of (see also p. 103.)	NiO.	O	Black.	Pale green ; insol.	Pale green ; solable, forming green solution.	Pale green ; insol.	Pale green ; solable, forming a blue solution.	Pale green.	With soda on charcoal, reduced to a magnetic powder. With borax and microcosmic salt in outer flame, red glass, becoming colorless on cooling.	Potash throws down a pale green precipitate from the ammoniacal solution.

Name of Base.	Sym- bol.	Hydro- sulphuric Acid (HS), in an acidified solution.	Hydro- sulphate of Ammonia (NH_4S , HS).	Carbonate of Soda (Na_2O , CO_2).	Carbonate of Ammonia ($2NH_4O$, $3CO_2$).	Potash (KO).	Ammonia (NH_3).	Ferro- cyanide of Potas- sium (K_4Fe Cy_6).	Blowpipe.	Remarks.
Osmium, deutoxide of.	OsO_4 .	Yellowish- brown, slowly formed.	Yellowish- brown; insol.	Black, slowly formed. Bluish solution.	Brown after some time.	Black on boiling.	Brown after some time.	○		Osmium is characterized by forming, when heated in the air, a suboxide, which is volatile, and has a very disagreeable smell, causing much inconvenience to the eyes and nose.
Palladium, protoxide of.	PdO .	Black.	Black; insol.	Brown; sol. Repre- cipitated on boiling.	Solution decolor- ized, but no precipitate.	Yellowish- brown sol.	Yellowish- brown; sol.	○	Reduced.	Yellowish-white with solution of cyanide of mer- cury.
Platinum, oxide of.	PtO_2 .	Brownish- black, formed slowly.	Brownish- black; sol. in large excess.	Yellow with car- bonate of potash.	Yellow.	Yellow.	Yellow.	○	Reduced.	Yellow with mu- riate of ammonia, which is converted by heat into spongy platinum.
Potash, (see also p. 87.)	KO .	○	○	○	○	○	○	○	Violet flame.	White crystalline precipitate with tartaric acid. Yellow, with bichloride of platinum.
Rhodium, sesquiox- ide of.	R_2O_3 .	Brown, formed slowly.	Brown; insol.	Yellowish after a time.	Yellowish after a time.	Yellowish- brown on boiling.	Yellowish after a time.	Dark orange.	Reduced.	Many of the compounds have a rose color.

Silver, oxide of, (see also p. 137.)	AgO.	Black.	Black.	White ; insol.	White ; sol.	Pale brown ; insol.	Pale brown ; sol.	White.	Reduced.	White curdy pre- cipite with hydro- chloric acid and chlorides, which is sol. in ammonia and insol. in nitric acid.
Soda, (see also p. 98.)	NaO.	○	○	○	○	○	○	○	Yellow flame.	The only salt which precipitates soda, is the anti- moniate of potash. Evapo- rated with bi- chloride of platinum, gives yellow needles.
Strontia, (see also p. 98.)	SrO.	○	○	White ; insol.	White ; insol.	○	○	○	Carmine flame.	White precipitate with sulphates. Burnt with alcohol, gives carmine flame.
Tin, peroxide of, (see also p. 128.)	SnO.	Brown black.	Brown black.	White ; insol.	White ; insol.	White ; sol.	White ; insol.	White.	With soda in reducing flame, a malleable bead of metallic tin.	Zinc throws down the metal in beautiful crystals.
Tin, peroxide of, (see also p. 130.)	SnO ₂ .	Yellow.	Yellow ; sol.	White ; insol.	White ; insol.	White ; sol.	White ; sol.	White.	Reduced with soda.	The behavior with hydrosul- phate of ammonia and the blowpipe is characteristic.

Name of Base.	Sym- bol.	Hydro- sulphuric (HS) in an acidified solution.	Hydro- sulphate of Ammonia (NH ₄ HS).	Carbonate of Soda (Na ₂ CO ₃).	Carbonate of Ammonia (NH ₄ CO ₃).	Potash (KO).	Ammonia (NH ₄).	Ferri- oxide of Ferri- um (Fe ₂ O ₃).	Reaction.	Remarks.
Uranium, peroxide of.	U ₂ O ₅ .	O (Sulphur.)	Black.	Yellow; sol.	Yellow; sol.	Yellow; insol.	Yellow; insol.	Reddish brown.	Yellow glass with borax.	When the precipi- tate with ammonia is heated, it is converted into the green protoxide.
Vanadium, black oxide of.	VO ₂ .	O	Brown- black; sol. in excess, forming a purple solution.	Dirty white.	Gray passing to brown.	Grayish- white.	Brown.	Yellow.	With borax, yellow in outer flame; in the inner, brown, becoming green when cold.	Many of the solutions have a blue color.
Yttria.	YO.	O	White.	White; sp. sol.	White; sp. sol.	White; insol.	White; insol.	White.	Nothing characteristic.	Copious white with oxalic acid.
Zinc, oxide of, (see also p. 103.)	ZnO.	O	White.	White; insol.	White; sol.	White; sol.	White; sol.	White.	With soda on char- coal gives a white sublimation of oxide, which is yellow when hot. With pit. cobalt, green.	Behavior with hydrosulphate of ammonia characteristic.
Zirconia.	ZrO ₂ .	O	White.	White after a time.	White; sol.	White; insol.	White; insol.	White.	Bright flame.	Oxalic acid gives a white precipitate.

2. METALLIC OXIDES HAVING ACID PROPERTIES.

Symbol (in parentheses)	Hydroxide (in parentheses)	Hydroxide of Ammonia (NH ₄ OH)	Chloride of Barium (BaCl ₂) (in alkaline salts of the acids)	Nitrate of Silver (AgNO ₃) (in alkaline salts of the acids)	Nitrate of Lime (Ca(NO ₃) ₂) (in alkaline salts of the acids)	Hydrochloric Acid (HCl)	Remarks.
Antimony trioxide (Sb ₂ O ₃)	Orange-red.	Orange-red.	White; sp. sol. in water.	White.	White; sp. sol. in water.	White.	Antimonious acid becomes pale yellow when heated, and white again on cooling. It is insoluble in alkali acids, and difficultly soluble in hot hydrochloric acid.
Antimony pentoxide (Sb ₂ O ₅)	Orange-red.	Orange-red.	White.	White.	White.	White.	Insoluble in water and alkali acids. Soluble in hydrochloric acid, from which it is precipitated on the addition of water. When strongly heated, gives off oxygen, and becomes antimonious oxide.
Antimony trioxide (Sb ₂ O ₃)	Yellow; soluble in alkali acids.	Yellow; soluble in alkali acids.	White.	White.	White.	White.	Insoluble in water and alkali acids. Soluble in hydrochloric acid, from which it is precipitated on the addition of water. When strongly heated, gives off oxygen, and becomes antimonious oxide.
Antimony pentoxide (Sb ₂ O ₅)	Yellow; soluble in alkali acids.	Yellow; soluble in alkali acids.	White.	White.	White.	White.	Insoluble in water and alkali acids. Soluble in hydrochloric acid, from which it is precipitated on the addition of water. When strongly heated, gives off oxygen, and becomes antimonious oxide.
Antimony trioxide (Sb ₂ O ₃)	Yellow; soluble in alkali acids.	Yellow; soluble in alkali acids.	White.	White.	White.	White.	Insoluble in water and alkali acids. Soluble in hydrochloric acid, from which it is precipitated on the addition of water. When strongly heated, gives off oxygen, and becomes antimonious oxide.
Antimony pentoxide (Sb ₂ O ₅)	Yellow; soluble in alkali acids.	Yellow; soluble in alkali acids.	White.	White.	White.	White.	Insoluble in water and alkali acids. Soluble in hydrochloric acid, from which it is precipitated on the addition of water. When strongly heated, gives off oxygen, and becomes antimonious oxide.

3. NON-METALLIC ACIDS.

Acids (neutralized).	Symbol.	Nitrate of Barium (BaO, NO ₃).	Nitrate of Silver (AgO, NO ₃).	Nitrate of Lime (CaO, NO ₃).	Acetate of Lead (PbO, C ₂ H ₃ O ₂).	Remarks.
Boric acid (see also p. 135.)	H ₃ BO ₃	White.	White.	White.	White.	Slightly volatile in the presence of aqueous vapor. Turns turmeric paper brown, and blue litmus port-wine color. Gives green color to the flame of alcohol.
Bromic acid.	HOBr	White.	White.	()	White.	The bromates are decomposed by heat into bromides and oxygen. Sulphuric acid disengages bromine.
Carbonic acid (see also p. 135.)	CO ₂	White.	White.	White.	White.	The carbonates are readily decomposed by acids, carbonic acid gas being given off with effervescence, which, when passed into lime water gives a white precipitate.
Chloric acid (see also p. 135.)	HOCl	()	()	()	()	All the chlorates are soluble in water. At a red heat they are converted into chlorides, oxygen being given off.
Iodic acid (see also p. 135.)	HOI	()	()	()	Bright yellow.	The iodides evolve iodine when heated with nitric or sulphuric acid. With chlorine water and starch they give a dark purple precipitate.
Phosphoric acid (see also p. 135.)	H ₃ PO ₄	Yellowish.	Yellowish.	()	White.	The bromides, when heated with nitric acid, evolve bromine.
Sulphuric acid (see also p. 135.)	H ₂ SO ₄	White.	White.	()	White.	The chlorides, when heated with peroxide of lead, or of manganese, evolve chlorine.
Telluric acid (see also p. 135.)	HO ₂ Te	White.	White.	()	White.	With a mixture of a proto-salt and peroxide of iron, the alkaline cyanides give a precipitate of prussian blue.
Vanillic acid (see also p. 135.)	HO ₂ C ₆ H ₃ CO ₂	White.	White.	White.	White.	The fluorides, when moistened with sulphuric acid, give off fumes which corrode glass.

Name of Base.	Sym- bol.	Hydro- sulphuric Acid (HS) in an acidified solution.	Hydro- sulphate of Ammonia (NH_4S , HS).	Carbonate of Soda (Na_2O , CO_2).	Carbonate of Ammonia ($2\text{NH}_4\text{O}$, 3CO_2).	Potash. (KO).	Ammonia (NH_3).	Ferro- cyanide of Potas- sium (K_4Fe C_6N_6).	Blowpipe.	Remarks.
Uranium, sesquioxide of.	U_2O_5 .	O (Sulphur).	Black.	Yellow; sol.	Yellow; sol.	Yellow; insol.	Yellow; insol.	Reddish brown.	Yellow glass with borax.	When the precipi- tate with ammonia is heated, it is converted into the green protoxide.
Vanadium, binoxide of.	VO_2 .	O	Brown- black; sol. in excess, forming a purple solution.	Dirty white.	Gray passing to brown.	Grayish- white.	Brown.	Yellow.	With borax, yellow in outer flame; in the inner, brown, becoming green when cold.	Many of the solutions have a blue color.
Yttria.	YO.	O	White.	White; sp. sol.	White; sp. sol.	White; insol.	White; insol.	White.	Nothing characteristic.	Copious white with oxalic acid.
Zinc, oxide of, (see also p. 103.)	ZnO .	O	White.	White; insol.	White; sol.	White; sol.	White; sol.	White.	With soda on char- coal gives a white sublimation of oxide, which is yellow when hot. With nit. cobalt, green.	Behavior with hydrosulphate of ammonia characteristic.
Zirconia.	Zr_2O_3 .	O	White.	White after a time.	White; sol.	White; insol.	White; insol.	White.	Bright flame.	Oxalic acid gives a white precipitate.

2. METALLIC OXIDES HAVING ACID PROPERTIES.

Acids (in combination).	Symbol.	Hydrosulphuric acid (H ₂ S) in acidified solutions.	Hydrosulphate of Ammonia (NH ₄ HS).	Chloride of Barium (BaCl ₂) in alkaline salts of the acids).	Nitrate of Silver (AgNO ₃) in alkaline salts of the acids).	Nitrate of Lime (CaNO ₃) in alkaline salts of the acids).	Hydrochloric Acid (HCl).	Remarks.
Antimonious acid.	SbO ₃ .	Orange.	Orange ; sol.	White ; sp. sol. in water.	White.	White ; sp. sol. in water.	White.	Antimonious acid becomes pale, yellow when heated, and white again on cooling. It is insoluble in nitric acid, and difficultly soluble in hot hydrochloric acid.
Antimonic acid.	SbO ₅ .	Orange.	Orange ; sol.	White.	White.	White.	White.	Insoluble in water and nitric acid. Soluble in hydrochloric acid, from which it is precipitated on the addition of water. When strongly heated, gives off oxygen, and becomes antimonious acid.
Arsenious acid, (see also p. 111.)	AsO ₃ .	Yellow ; soluble in alkalies and alkaline sulphides.	Yellow ; sol.	White.	Pale yellow.	White.	O	Volatilizes at a low heat, and condenses in octoëdral crystals. The best tests are Marsh's and Reinsch's. (See p. 114.)
Arsenic acid, (see also p. 118.)	AsO ₅ .	Yellow ; soluble in alkalies and alkaline sulphides.	Yellow ; sol.	White.	Chocolate-brown.	White.	O	Heated with black flux gives metallic arsenic.

Acids (in combination).	Symbol.	Hydrosulphuric acid (HS) in acidified solutions.	Hydrosulphate of Ammonia (NH_4S , HS).	Chloride of Barium ($BaCl_2$) in alkaline salts of the acids).	Nitrate of Silver ($AgNO_3$) in alkaline salts of the acids).	Nitrate of Lime (CaO , NO_3) in alkaline salts of the acids).	Hydrochloric Acid (HCl).	Remarks.
Chromic acid.	CrO_3 .	Reduced to oxide, with precipitation of sulphur.	Green.	Yellow.	Reddish-brown.	Yellow in concentrated solutions.	Reduced to oxide, with evolution of chlorine.	In decomposed by heat and by deoxidizing agents, into oxide of chromium. Salts of lead throw down a yellow precipitate.
Manganic acid.	MnO_2 .	O	Flesh-colored.	O	Black (oxide).	Black.	Solution becomes red, and chlorine is evolved.	Converted by acids into hypermanganic acid and peroxide of manganese; the color of the solution changing from green to red.
Molybdic acid.	MnO_2 .	Brown.	Brown; sol.	White.	White.	White.	White.	With microcosmic salt before the blowpipe, gives a dark blue glass, which becomes green on cooling. When strongly heated, molybdic acid volatilizes and condenses in crystals.
Tungstic acid.	WO_3 .	Slight turbidity.	Brown; sol.	White.	White.	White.	White; insol.	Does not volatilize when heated. Has a pale yellow color, and is insoluble in water and acids.
Vanadic acid.	VO_3 .	Gray.	Brown; sol.	Orange.	Yellow.	O	Chlorine evolved.	When treated with hydrochloric acid, the mixture is capable of dissolving gold leaf. Vanadic acid in solution is readily deoxidized, forming a blue liquid.

TABLE XIII.

Showing the Behavior of Solutions of the Metals with Hydrosulphuric Acid, Hydrosulphate of Ammonia, and Carbonate of Ammonia, employed successively. (Dr. Wüll.)—(The rarer metals are printed in italics.)

Bodies precipitated by HYDROSULPHATE OF AMMONIA.			Bodies not precipitated by Hydrosulphuric Acid or Hydrosulphate of Ammonia.
As Sulphides.	As Oxides.	As Salts.	
Insoluble in Hydrosulphuric Acid, as Sulphides. Soluble in Hydrosulphate of Ammonia, and reprecipitated by Hydrochloric Acid.	As Sulphides. Nickel } Black. Cobalt } Manganese } Flesh-colored. Iron . . Black. Zinc . . White. Uranium } Brownish-black.	As Oxides. Alumina Glucina Chromium Thorina Yttria Cerium Zirconia Titanium Tantalum	Bodies not precipitated by Hydrosulphuric Acid or Hydrosulphate of Ammonia. In the presence of Muriate of Ammonia, on addition of CARBONATE OF AMMONIA, precipitate: not precipitated: Baryta. Magnesia. Strontia. Potash. Lime. Soda. Lithia. Ammonia.
Elements precipitated from their acid solution by HYDROSULPHURIC ACID, as Sulphides. Soluble in Hydrosulphate of Ammonia, and reprecipitated by Hydrochloric Acid.	Insoluble in Hydrosulphuric Acid, as Sulphides. Mercury Silver Lead Bismuth Copper Cadmium Palladium Rhodium Osmium	As Oxides. Black or brownish-black. Yellow.	Bodies not precipitated by Hydrosulphuric Acid or Hydrosulphate of Ammonia.
Antimony Orange. Arsenic } Yellow. Tin } Gold } Black. Platinum } Iridium }			
Molybdenum Brown.			

Acids (neutralized).	Symbol.	Nitrate of Barium (BaO, NO ₂).	Nitrate of Silver (AgO, NO ₂).	Nitrate of Lime (CaO, NO ₂).	Acetate of Lead (PbO, C ₂ H ₃ O ₂).	Remarks.
Hydroselenic acid.	HS ₂ .	O	Black.	O	Black.	The selenides, when heated in the outer flame of the blowpipe, evolve the odor of selenium, resembling that of putrid horse-radish.
Hydrosulphuric acid, (see also p. 140.)	HS.	O	Black.	O	Black.	Most of the sulphides, when treated with an acid, evolve hydrosulphuric acid, which smells like rotten eggs.
Hyposulphurous acid.	S ₂ O ₃ .	White.	White, becoming brown.	O	White.	The hyposulphites are decomposed by hydrochloric acid; sulphur is precipitated, and sulphurous acid set free.
Hyposulphuric acid.	S ₂ O ₄ .	O	O	O	O	The hyposulphates are decomposed without deposition of sulphur, when boiled with hydrochloric acid; sulphurous and sulphuric acids are formed.
Iodic acid.	IO ₃ .	White.	White.	White.	White.	The iodates are decomposed by heat into iodides and oxygen.
Nitric acid, (see also p. 142.)	NO ₃ .	O	O	O	O	When mixed with sulphuric and hydrochloric acids, the nitrates dissolve gold leaf. With copper filings and sulphuric acid, orange fumes are given off.
Perchloric acid.	ClO ₄ .	O	O	O	O	The perchlorates are resolved by heat into chlorides and oxygen. They are not decomposed in the cold by hydrochloric or sulphuric acid; thus differing from the chlorates.
Phosphoric acid, (tribasic, (see also p. 134.)	PO ₄ .	White.	Pale yellow.	White.	White.	The soluble phosphates give with salts of magnesia, when ammonia is present, a white crystalline precipitate.

(d.) Mixed Salts, &c., soluble in Water.

{ Chloride of barium,	{ Sulphate of nickel,
{ Nitrate of potash.	{ Chloride of sodium,
{ Sulphate of zinc,	{ Sulphate of magnesia.
{ Chloride of sodium.	{ Chlorate of potash,
{ Muriate of ammonia,	{ Biborate of soda,
{ Phosphate of soda.	{ Muriate of ammonia,
{ Sulphate of copper,	{ Arsenious acid.
{ Nitrate of cobalt.	{ Nitrate of soda,
{ Perchloride of iron,	{ Nitrate of lime,
{ Sulphate of magnesia.	{ Nitrate of baryta,
	{ Nitrate of zinc,
	{ Nitrate of lead,
	{ Nitrate of copper.
Alum (double sulphate of alumina and potash).	{ Sulphate of potash,
	{ Phosphate of soda,
{ Chloride of calcium,	{ Biborate of soda,
{ Nitrate of potash,	{ Carbonate of ammonia,
{ Muriate of ammonia.	{ Chloride of potassium,
{ Nitrate of lead,	{ Iodide of potassium,
{ Nitrate of cobalt,	{ Nitrate of ammonia.
{ Nitrate of strontia.	

(e.) Mixed Salts, &c., insoluble in Water, but soluble in Acids.

{ Carbonate of magnesia,	Magnesian limestone.
{ Sulphide of iron.	Iron pyrites.
{ Protoxide of lead,	Copper pyrites.
{ Phosphate of lime.	Argentiferous galena.
{ Carbonate of lime,	German silver.
{ Black oxide of copper.	Arsenical cobalt ore.
Brass.	The solid matter contained in sea,
{ Oxide of bismuth,	well, or river water.
{ Sulphide of iron,	The portion of soils which is solu-
{ Sulphide of antimony.	ble in acids.

(f.) Mixed Salts, &c., insoluble in Water and Acids.

{ Chloride of silver,	{ Sulphate of lead,
{ Sulphate of baryta.	{ Silicate of alumina,
{ Silica,	{ Chloride of silver.
{ Chloride of lead.	The insoluble portion of soils.
	Slate.
	Siliceous minerals.

Acids (neutralized).	Symbol.	Chloride of Calcium (CaCl ₂).	Perchloride of Iron (Fe ₂ Cl ₆).	Nitrate of Barium (BaO, NO ₂).	Nitrate of Silver (AgO, NO ₂).	Acetate of Lead (PbO, C ₂ H ₃ O ₂).	Remarks.
Benzoic acid, (see also p. 150.)	HO, C ₇ H ₅ O ₂ .	○	Brownish- yellow.	○	Crystalline in concentrated neutral solutions.	White in concentrated neutral solutions.	Solutions of the benzoates, when treated with sulphuric acid, give a crystalline precipitate of benzoic acid.
Citric acid, (see also p. 148.)	3HO, C ₆ H ₇ O ₇ .	White.	○	White.	White.	White.	With protochlorate of mercury, a white precipi- tate, which becomes gray.
Formic acid, (see also p. 152.)	HO, C ₂ H ₃ O ₂ .	○	○	○	White; becom- ing black, especially when warmed.	○	The formates, when warmed with sulphuric acid, do not blacken, and give off carbonic oxide gas.
Malic acid, (see also p. 149.)	2HO, C ₄ H ₅ O ₄ .	White on the addi- tion of alcohol.	○	White.	White; becoming gray.	White precipitate that melts in boiling water.	Malate of lead dissolves in hot dilute acetic acid, and crystallizes on cooling in fine needles. Malic acid is decomposed by heat, into malic and fumaric acids.
Oxalic acid, (see also p. 145.)	HO, C ₂ O ₃ .	White.	Yellowish- brown.	White; crystalline.	White.	White.	Neither the acid nor the oxalates are black- ened by strong sulphuric acid, but give off car- bonic acid and carbonic oxide gases.
Succinic acid, (see also p. 150.)	HO, C ₄ H ₅ O ₄ .	○	Reddish- brown.	○	White on standing.	White.	A mixture of chloride of barium, ammonia, and alcohol, gives a white precipitate of succi- nate of baryta.
Tartaric acid, (see also p. 147.)	2HO, C ₄ H ₄ O ₆ .	White.	○	White.	White.	White.	Added in excess to potash, gives a crystalline precipitate of the bitartrate.

TABLE XIII.

Showing the Behavior of Solutions of the Metals with Hydrosulphuric Acid, Hydrosulphate of Ammonia, and Carbonate of Ammonia, employed successively. (Dr. Will.)—(The rarer metals are printed in Italics.)

Bodies precipitated by HYDROSULPHATE OF AMMONIA.			Bodies not precipitated by Hydrosulphuric Acid or Hydrosulphate of Ammonia.
As Sulphides.	As Oxides.	As Salts.	
<p>Elements precipitated from their acid solution by Hydrosulphuric Acid, as Sulphides.</p> <p>Soluble in Hydrosulphate of Ammonia, and reprecipitated by Hydrochloric Acid.</p> <p>Antimony Orange.</p> <p>Arsenic } Yellow.</p> <p>Tin }</p> <p>Gold }</p> <p>Platinum } Black.</p> <p>Iridium }</p> <p>Molybdenum Brown.</p>	<p>Alumina } Soluble in potash.</p> <p>Glucina }</p> <p>Chromium }</p> <p>Thorina }</p> <p>Yttria }</p> <p>Cerium }</p> <p>Zirconia }</p> <p>Titanium }</p> <p>Tantalum }</p> <p>Insoluble in potash.</p>	<p>Baryta, Strontia, Lime, in combination with phosphoric, boracic, oxalic, and some other acids.</p> <p>Magnesia in combination with phosphoric acid.</p>	<p>Mercury } Black or brownish-black.</p> <p>Silver }</p> <p>Lead }</p> <p>Bismuth }</p> <p>Copper }</p> <p>Cadmium } Yellow.</p> <p>Palladium }</p> <p>Rhodium }</p> <p>Osmium }</p> <p>Brownish-black.</p>
<p>Nickel } Black.</p> <p>Cobalt }</p> <p>Manganese } Flesh-colored.</p> <p>Iron . . Black.</p> <p>Zinc . . White.</p> <p>Uranium } Brownish-black.</p>			<p>precipitated: are</p> <p>Baryta. Magnesia.</p> <p>Strontia. Potash.</p> <p>Lime. Soda.</p> <p><i>Lithia.</i></p> <p>Ammonia.</p>

LIST OF SALTS, ETC.

WHICH MAY BE EXAMINED FOR PRACTICE IN QUANTITATIVE ANALYSIS
(Part III.)

(a.) Simple Salts, &c., soluble in Water.

Chloride of barium.	Protonitrate of mercury.
Sulphate of soda.	Perchloride of mercury.
Muriate of ammonia.	Acetate of lead.
Sulphate of magnesia.	Sulphate of copper.
Chloride of calcium.	Nitrate of silver.
Nitrate of strontia.	Phosphate of soda.
Sulphate of chromium.	Iodide of potassium.
Sulphate of zinc.	Biborate of soda.
Sulphate of manganese.	Nitrate of potash.
Protosulphate of iron.	Chlorate of potash.
Perchloride of iron.	Carbonate of soda.
Sulphate of nickel.	Arsenious acid.
Nitrate of cobalt.	

(b.) Simple Salts, &c., insoluble in Water, but soluble in Acids.

Carbonate of magnesia.	Protoxide of lead.
Phosphate of lime.	Sulphide of antimony.
Carbonate of baryta.	Black oxide of copper.
Metallic zinc.	Carbonate of lime.
Carbonate of strontia.	Oxide of bismuth.
Sulphide of iron.	Metallic tin.

(c.) Simple Salts, &c., insoluble in Water and Acids.

Sulphate of baryta.	Silica.
Sulphate of strontia.	Chloride of silver.
Chloride of lead.	Silicate of lime.
Sulphate of lead.	Silicate of alumina.

ISOMERIC, from *Isos*, equal, and *μερος*, a part; substances which consist of the same ingredients, in the same proportions, and yet differ essentially in their properties, are called *isomeric*.

LAMINÆ, from *lamina*, a thin plate; extremely thin plates, of which some solid bodies are composed.

LEVIGATION, from *levis*, smooth; the reducing of hard bodies to a very fine powder, by grinding with water.

LIGNIN, from *lignum*, wood; an organic principle of which the fibres of vegetables are mainly composed.

LITMUS; a blue pigment obtained from the lichen *roccella*; it is a most delicate test for acids, which turn it red.

MALLEABLE, from *malleus*, a hammer; that which is capable of being spread out by hammering.

METALLURGY, from *μέταλλον*, a metal, and *εργον*, a work; the art of working metals, and separating them from their ores.

MOLECULES, -*AE*, a diminutive from *moles*, a mass; the infinitely small material particles, of which bodies are conceived to be aggregations.

MUCILAGINOUS; resembling mucilage or gum.

MUREXIDE, from *murex*, a fish affording a purple dye; a beautiful purple compound, resulting from the decomposition of uric acid by means of nitric acid.

NASCENT, from *nascor*, to be born; in the moment of formation.

NITROGEN, from *nitro*, nitre, and *γενειν*, to produce; a colorless elementary gas, devoid of taste and smell; it is one of the constituents of the atmosphere, and also of nitric acid, from which latter circumstance it derives its name.

NITROGENOUS; containing nitrogen in combination.

NUCLEUS, from *nucleus*, a kernel; the central parts of a body, which are supposed to be firmer, and separated from the other parts, as the kernel of a nut is from the shell; also, the point about which matter is collected.

OCTOEDRON, -*AL*, from *ὀκτώ*, eight, and *ἑδρα*, a side; a solid figure contained by eight equal and equilateral triangles.

OLEFIANT GAS, from *oleum*, oil, and *fit*, to become; a colorless gas, composed of carbon and hydrogen (C_4H_4), which derives its name from its property of forming an oil-like liquid with chlorine.

ORGANIC MATTER, from *εργασιον*, an organ; matter of which the organic parts or juices of plants and animals are composed, or which is derived from such parts by the action of chemical agents, is called *organic*.

OXIDE; a compound of oxygen with a metal or non-metallic body, not having acid properties.

OXIDIZE; to combine with oxygen.

OXYGEN, from *ἔξω*, acid, and *γενειν*, to produce; a colorless, elementary gas, which was formerly supposed to be the universal acidifying principle.

PELLICLE, a diminutive from *pellis*, a skin or crust; a thin crust formed on the surface of a solution by evaporation.

PERCOLATE, from *per*, through, and *colo*, to strain; to strain through.

PERMEATE, from *permeo*, to pass through; to penetrate.

PHENOMENON, from *φαίνεμαι*, to appear; an appearance which is more or less remarkable.

PHILOSOPHY, from *φιλέω*, to love, and *σοφία*, wisdom; the study or knowledge of nature or morality, founded on reason and experience; the word originally implying "A love of wisdom."

PHLOGISTON, from *φλέω*, to burn; a name given by the older chemists to an imaginary substance, which was considered as the principle of inflammability.

PHOSPHORUS, from *φῶς*, light, and *φείω*, to produce; a highly inflammable elementary substance, obtained from calcined bones, which emits light when placed in the dark, owing to its undergoing a slow combustion.

PHYSICS, -ICAL, from *φύσις*, nature; the science of natural bodies, their phenomena, causes, and effects, with their affections, motions, and operations.

PNEUMATICS, from *πνεῦμα*, air; that branch of Natural Philosophy which treats of the weight, elasticity, and other properties of æriform fluids.

POLARITY; the opposition of two equal forces in bodies, similar to that which confers the tendency of magnetized bodies to point towards the magnetic poles.

POLARIZED LIGHT; light, which by reflection or refraction at a certain angle, or by refraction in certain crystals, has acquired the property of exhibiting opposite effects in planes at right angles to each other, is said to be *polarized*.

PORES, from *πόρος*, a passage; the small interstices between the solid particles of bodies.

PRECIPITATION, from *præcipitō*, to fall suddenly; the formation and separation of a solid substance in a liquid.

PRODUCT, from *pro*, forth, and *duco*, to draw; anything formed from the elements of another by an operation.

PYRO, from *πῦρ*, fire; when prefixed to a word, denotes that the substance which it signifies, has been formed at a high temperature.

QUALITATIVE; regarding the properties of a body, and the kinds of matter of which it is composed, without reference to quantity.

QUANTITATIVE; regarding quantities.

RADIATION, from *radius*, a ray; the shooting forth in all directions from a centre.

RAREFACTION, from *rarus*, rare, and *facio*, to make; the act of causing a substance to become less dense; it also denominates the state of this lessened density.

RECTIFICATION; the process of drawing anything off by distillation, in order to obtain it in a state of greater purity.

REFRACTION, from *re*, back, and *frango*, to break; the deviation of rays of

light or heat from their direct course, when passing through media of different densities.

REFRIGERATION, from *re*, again, and *frigus*, cold; the act of cooling.

REPULSION, from *re*, back, and *pello*, to drive; that property in certain bodies whereby they mutually tend to recede from each other.

SALIFIABLE BASES, from *sal*, salt, and *fit*, to become; bodies capable of combining with acids, to form salts.

SAPID, from *sapio*, to taste of; possessing the power of exciting the organs of taste.

SATURATION, -ATED, from *satur*, full; the solution of one body in another until the receiving body can contain no more. A solution is said to be saturated with an acid or an alkali, when the latter is added in sufficient quantity to render it neutral, and *supersaturated* when the point of neutrality has been exceeded.

SOLUTION, from *solvere*, to loosen or melt; any liquid which contains another substance dissolved in it.

SOLVENT; any substance which will dissolve another.

SPECIFIC, from *species*, a particular sort or kind; that which denominates any property which is not general, but is confined to an individual or species.

SPECIFIC GRAVITY; see **GRAVITY, SPECIFIC**.

SUBLIMATION, from *sublimis*, high; the act of raising into vapor by means of heat, and condensing in the upper part of the vessel.

SULPHIDE; a combination of a metal with sulphur.

SUPERSATURATE; see **SATURATION**.

TERNARY, from *ter*, thrice; containing three units.

TETRAHEDRON, from *tetrago*, four, and *hedra*, a base or side; a solid figure contained by four equal and equilateral triangles.

TRANSPARENT; a term to denote the quality of a substance which not only admits the passage of light, but also of the vision of external objects.

TRITURATE, from *trituro*, to thresh; to reduce to powder.

VACUUM, from *vacuus*, empty; a space empty, and devoid of all matter.

VOLUME, from *volumen*, a roll; the apparent space occupied by a body.

WEIGHT; the pressure which a body exerts vertically downwards, in consequence of the action of gravity.

ZERO; the numeral 0, which fills the blank between the ascending and descending numbers of a series.

	PAGE
Acid, sulphuric, uses of	232
“ “ impurities in	232
“ “ detected	169, 175, 190
“ “ Table of specific gravities of	253
“ tartaric, action of reagents on	147
“ “ impurities in	237
“ “ uses of	237
“ for Alkalimetry	76
Acidimetry	78
Acids, classification of	85
“ inorganic, action of reagents on	134
“ organic, action of reagents on	145
Alcohol	249
“ Table of specific gravities of	258
Alkalies, action of reagents on	86
Alkalimetry	75
Alkaline earths, action of reagents on	92
Alumina, action of reagents on	100, 265
“ blowpipe test for	101
“ detected	166, 167 173, 185
Ammonia, action of reagents on	89
“ distillation of	46
“ impurities in	237
“ uses of	237
“ detected	168, 188
“ Table of specific gravities of	257
“ carbonate	238
“ hydrosulphate	238
“ muriate, formation of	40
“ oxalate, uses of	239
Ammoniacal gas, prepared and experimented with	39
Ammonio-nitrate of silver	247
Ammonio-sulphate of copper	246
Ammonium and platinum, double chloride of	90
Analysis of simple soluble salts	163
“ simple salts, soluble in acids	171
“ simple insoluble salts	176
“ mixed soluble salts	180
“ mixed salts, soluble in acids	192
“ mixed insoluble salts	196
“ sulphate of copper	213
“ chloride of potassium	214
“ mixture of sulph. copper and chlor. sodium	216
“ mixture of sulph. zinc and carb. baryta	218
“ magnesian limestone	220
“ copper pyrites	223
“ gunpowder	72
“ carbonates	81
Annealing glass	52
Antimony, oxide of, action of reagents on	120, 265
“ distinguished from arsenic	117
“ detected	165, 183
Antimoniate of potash	243
Antimonic acid, action of reagents on	273
Antimonious acid, action of reagents on	273
Antimoniuretted hydrogen	121
Apparatus cleaned	xxi
“ labelled	xix, 180

1. NAME
 2. ADDRESS
 3. CITY
 4. STATE
 5. ZIP
 6. PHONE
 7. TELETYPE
 8. FAX
 9. EMAIL
 10. DATE
 11. TIME
 12. LOCATION
 13. REMARKS
 14. INITIALS
 15. SIGNATURE
 16. DATE
 17. TIME
 18. LOCATION
 19. REMARKS
 20. INITIALS
 21. SIGNATURE
 22. DATE
 23. TIME
 24. LOCATION
 25. REMARKS
 26. INITIALS
 27. SIGNATURE
 28. DATE
 29. TIME
 30. LOCATION
 31. REMARKS
 32. INITIALS
 33. SIGNATURE
 34. DATE
 35. TIME
 36. LOCATION
 37. REMARKS
 38. INITIALS
 39. SIGNATURE
 40. DATE
 41. TIME
 42. LOCATION
 43. REMARKS
 44. INITIALS
 45. SIGNATURE
 46. DATE
 47. TIME
 48. LOCATION
 49. REMARKS
 50. INITIALS
 51. SIGNATURE
 52. DATE
 53. TIME
 54. LOCATION
 55. REMARKS
 56. INITIALS
 57. SIGNATURE
 58. DATE
 59. TIME
 60. LOCATION
 61. REMARKS
 62. INITIALS
 63. SIGNATURE
 64. DATE
 65. TIME
 66. LOCATION
 67. REMARKS
 68. INITIALS
 69. SIGNATURE
 70. DATE
 71. TIME
 72. LOCATION
 73. REMARKS
 74. INITIALS
 75. SIGNATURE
 76. DATE
 77. TIME
 78. LOCATION
 79. REMARKS
 80. INITIALS
 81. SIGNATURE
 82. DATE
 83. TIME
 84. LOCATION
 85. REMARKS
 86. INITIALS
 87. SIGNATURE
 88. DATE
 89. TIME
 90. LOCATION
 91. REMARKS
 92. INITIALS
 93. SIGNATURE
 94. DATE
 95. TIME
 96. LOCATION
 97. REMARKS
 98. INITIALS
 99. SIGNATURE
 100. DATE
 101. TIME
 102. LOCATION
 103. REMARKS
 104. INITIALS
 105. SIGNATURE
 106. DATE
 107. TIME
 108. LOCATION
 109. REMARKS
 110. INITIALS
 111. SIGNATURE
 112. DATE
 113. TIME
 114. LOCATION
 115. REMARKS
 116. INITIALS
 117. SIGNATURE
 118. DATE
 119. TIME
 120. LOCATION
 121. REMARKS
 122. INITIALS
 123. SIGNATURE
 124. DATE
 125. TIME
 126. LOCATION
 127. REMARKS
 128. INITIALS
 129. SIGNATURE
 130. DATE
 131. TIME
 132. LOCATION
 133. REMARKS
 134. INITIALS
 135. SIGNATURE
 136. DATE
 137. TIME
 138. LOCATION
 139. REMARKS
 140. INITIALS
 141. SIGNATURE
 142. DATE
 143. TIME
 144. LOCATION
 145. REMARKS
 146. INITIALS
 147. SIGNATURE
 148. DATE
 149. TIME
 150. LOCATION
 151. REMARKS
 152. INITIALS
 153. SIGNATURE
 154. DATE
 155. TIME
 156. LOCATION
 157. REMARKS
 158. INITIALS
 159. SIGNATURE
 160. DATE
 161. TIME
 162. LOCATION
 163. REMARKS
 164. INITIALS
 165. SIGNATURE
 166. DATE
 167. TIME
 168. LOCATION
 169. REMARKS
 170. INITIALS
 171. SIGNATURE
 172. DATE
 173. TIME
 174. LOCATION
 175. REMARKS
 176. INITIALS
 177. SIGNATURE
 178. DATE
 179. TIME
 180. LOCATION
 181. REMARKS
 182. INITIALS
 183. SIGNATURE
 184. DATE
 185. TIME
 186. LOCATION
 187. REMARKS
 188. INITIALS
 189. SIGNATURE
 190. DATE
 191. TIME
 192. LOCATION
 193. REMARKS
 194. INITIALS
 195. SIGNATURE
 196. DATE
 197. TIME
 198. LOCATION
 199. REMARKS
 200. INITIALS
 201. SIGNATURE
 202. DATE
 203. TIME
 204. LOCATION
 205. REMARKS
 206. INITIALS
 207. SIGNATURE
 208. DATE
 209. TIME
 210. LOCATION
 211. REMARKS
 212. INITIALS
 213. SIGNATURE
 214. DATE
 215. TIME
 216. LOCATION
 217. REMARKS
 218. INITIALS
 219. SIGNATURE
 220. DATE
 221. TIME
 222. LOCATION
 223. REMARKS
 224. INITIALS
 225. SIGNATURE
 226. DATE
 227. TIME
 228. LOCATION
 229. REMARKS
 230. INITIALS
 231. SIGNATURE
 232. DATE
 233. TIME
 234. LOCATION
 235. REMARKS
 236. INITIALS
 237. SIGNATURE
 238. DATE
 239. TIME
 240. LOCATION
 241. REMARKS
 242. INITIALS
 243. SIGNATURE
 244. DATE
 245. TIME
 246. LOCATION
 247. REMARKS
 248. INITIALS
 249. SIGNATURE
 250. DATE

	PAGE
Calculus, fusible	229
“ oxalate of lime	229
“ phosphate of lime	227
“ triple phosphate	228
“ urate of ammonia	227
“ uric acid	226
Calomel, behavior with reagents	121
Caoutchouc connectors, how made	71
Carbonate of ammonia, uses of	238
“ “ impurities in	238
“ potash, impurities in	240
“ soda, impurities in	243
“ “ fusion with	196
Carbonates, analysis of	81
Carbonic acid, action of reagents on	136, 275
“ detected	169, 189
“ prepared and experimented with	28
“ substances heated in	72
“ in carbonates, estimated	81
Carbonic oxide, prepared and experimented with	33
Charcoal support	60
“ specific gravity of	67
Chemical equations	xviii
“ equivalents	xiv
“ symbols	xiv
“ terms, Glossary of	282
Chloric acid, action of reagents on	144, 275
“ detected	170, 191
Chloride of barium	245
“ calcium	245
Chlorine, estimation of	215
“ generated	73
Chromate of potash	212
Chromic acid, action of reagents on	274
Chromium, oxide, action of reagents on	101, 266
“ “ detected	167, 172, 185
“ “ Dichroism of its compounds	101
Citric acid, action of reagents on	148, 278
Classification of bases and acids	84
Cleaning apparatus	xxi
Cleanliness, importance of	xx
Cobalt, oxide, action of reagents on	109, 266
“ detected	166, 172, 186
“ nitrate	246
Copper, oxide, action of reagents on	126, 267
“ ammonio-sulphate	126, 246
“ arsenite	113
“ detected	164, 184
“ estimation of	213, 216
“ hydrated oxide	127
“ pyrites, analysis of	223
“ sulphate, analysis of	213
“ “ a reagent	246
Cork boring	70
Cork, specific gravity of	67
Crucible-jacket	210
Crucible, platinum	177, 210
Crystals of arsenious acid	111

INDEX.

295

	PAGE
Crystals of tin	131
Cupellation with the blowpipe	63
Cyanide of potassium	242

D

Decantation of gases	27
“ washing precipitates by	207
Deflagrating spoon	36
Desiccation in vacuo	208
Dichroism of salts of chromium	101
Discoloration of glass, removed	50
Distillation of ammonia	46
“ hydrochloric acid	45
“ nitric acid	47
“ water	41
“ in tubes	161
Double filters	206
Dropping-bottle	79
Drying	199

E

Earthy phosphates, detected	173, 194
Equations	xviii
Equivalents, chemical	xiv
Ether, Table of specific gravities of	259
Evaporation	207
Examination of calcoli	226
Experiments with the mouth blowpipe	57

F

Ferridcyanide of potassium	242
Ferrocyanide of potassium	242
Ferrocyanogen	106
Filters, burning of	206
“ ashes estimated	206
“ moistened	43, 203
“ folded	43, 203
“ double	206
Filtering hot solutions	205
Filtering blocks	79, 204
Filtering-ring	203
Filtration	202
Flame, Oxidizing and Reducing	49
Flasks, uses of	201
Formic acid, action of reagents on	152, 278
Freezing mixtures, Table of	260
French Weights and Measures	252
Funnels	203
Fusible calculus	229
Fusion with carbonate of soda	196

G.

	PAGE
Gas, ammoniacal, prepared and experimented with	39
Gas and air, mixture of	211
“ hydrochloric acid, prepared and experimented with	37
“ olefiant	32
Gaseous manipulation	25
Gases, dried	70
Gases, soluble, preparation of	37
“ substances heated in	69
“ transferred	27
Gasholder, Pepys's	25
General rules	xix
Glass, annealed	52
“ bending of	51
“ bulbs made	55
“ rods joined	51
“ stirrers made	50
“ syphon made	51
“ tube heated	50
“ “ hermetically sealed	56
“ tubes joined	53
Glass-working	48
Glasses cleaned	xxi
“ precipitating	202
Glossary of chemical terms	282
Glucina, action of reagents on	267
Gold, perchloride	248
“ oxide, action of reagents on	267
Gravity, specific; see Specific gravity	
Gunpowder, analysis of	72

H

Handles of paper for tubes	90
Heating in gases	
“ substances in carbonic acid	
Hydrated salts, estimation of water in	214
Hydriodic acid, action of reagents on	139, 275
“ “ detected	169, 170
Hydrobromic acid, action of reagents on	275
Hydrochloric acid, distillation of	45, 275
“ uses of	233
“ action of reagents on	138
“ impurities in	233
“ detected	170, 174, 191
“ table of specific gravities of	255
“ gas, prepared and experimented with	37, 275
Hydrocyanic acid, action of reagents on	275
Hydrofluoric acid, action of reagents on	275
Hydrogen, prepared and experimented with	26
“ reduction of metallic oxides in	69
Hydroselenic acid, action of reagents on	276
Hydrosulphate of ammonia	238
Hydrosulphuric acid, preparation of	234, 276
“ action of reagents on	140
“ uses of	235
“ detected	169, 174, 189

	PAGE
Hydrosulphuric acid apparatus, tubes prepared	54
Hyposulphuric acid, action of reagents on	276
Hyposulphurous acid, action of reagents on	276

I

Ignition	210
Imperial Measure	251
Indian rubber connectors, made	71
Indigo, sulphate	248
Inorganic acids, action of reagents on	132
Iodic acid, action of reagents on	276
Iodide of potassium	241
Iodine, detected	139, 169, 170, 174, 191
Iridium, oxide, action of reagents on	267
Iron, detected	166, 172, 185
" estimation of	220, 225
" perchloride, prepared	73
" uses of	246
Iron, peroxide, action of reagents on	106
" protoxide, action of reagents on	105

J

Jacket, crucible	210
Jet, specific gravity of	66
Joining glass tubes	53

L

Labelling, necessity of	xix, 180
Lamp, gas	210
" mixture of gas and air	211
" Rose's	211
" Solly's	211
Lead, oxide, action of reagents on	124, 268
" detected	164, 181, 183
" acetate	246
" chloride	125
" chlorosulphide	126
" chromate	126
" iodide	126
" phosphate	135
" subacetate	246
" sulphate	125
Lime, action of reagents on	94
" water	244
" estimation of	221
" detected	168
" carbonate, decomposed by heat	61
" oxalate	96
" phosphate	95
" sulphate	95, 244
Liquids, heated in tubes	90
" hermetically sealed in tubes	56

	PAGE
Liquids, preliminary examination of	160
Lithia, action of reagents on	268
Lithic acid calculus	226

M

Magnesia, action of reagents on	92, 268
“ blowpipe test for	94
“ estimation of	222
“ ammonio-phosphate of	93
“ detected	167, 189
Magnesian limestone, analysis of	220
Malic acid, action of reagents on	149, 278
Manganese, protoxide, action of reagents on	103, 269
“ blowpipe test for	104
“ detected	166, 172, 186
Manganic acid, action of reagents on	274
Marble, specific gravity of	66
Marsh's test for arsenic	114
Measures, Imperial	251
“ “ weight of water contained in	251
“ “ cubic inches contained in	252
Mercury, protoxide, action of reagents on	121, 269
“ peroxide, action of reagents on	123, 269
“ detected	164, 165, 181, 184
“ perchloride, reagent	248
“ red oxide, decomposed by heat	59
“ periodide	124
Metallic oxides, action of reagents on	86
Method, importance of	xix
Microcosmic salt	239
Molybdenum, oxide, action of reagents on	269
Molybdic acid, action of reagents on	274
Mouth blowpipe, how used	57
“ experiments with	57
Muriate of ammonia, formation of	40

N

Nickel oxide, action of reagents on	108, 269
“ detected	166, 172, 186
Nitrate of baryta	245
“ cobalt	246
“ potash, impurities in	241
“ silver, impurities in	247
Nitric acid, distillation of	47
“ uses of	234
“ action of reagents on	142, 276
“ impurities in	233
“ detected	170, 191
“ Table of specific gravities of	254
Nitrogen, binoxide of, prepared and experimented with	31
Nitrohydrochloric acid	234
Notes, importance of making	xix, 155

O

	PAGE
Oil bath	209
Olefant gas, prepared and experimented with	32
Organic acids, action of reagents on	145
“ mixtures, detection of arsenic in	119
Osmium, oxide, action of reagents on	270
Oxalate of ammonia, uses of	239
Oxalate of lime calculus	229
Oxalic acid, action of reagents on	145, 278
“ impurities in	236
Oxidizing flame	50
Oxides, metallic, reduced by hydrogen	69
“ “ action of reagents on	86
Oxygen, prepared and experimented with	35

P

Palladium, oxide, action of reagents on	270
Pepys's gasholder	25
Perchloric acid, action of reagents on	276
Perchloride of gold	248
“ of iron, prepared	73
“ “ a reagent	246
“ of mercury	247
Phosphates, earthy, detected	173, 193
Phosphate of ammonia and magnesia calculus	228
Phosphate of lime calculus	227
“ of soda	243
“ of soda and ammonia	239
Phosphoric acid, action of reagents on	134, 276
“ detected	170, 175, 190, 195
Phosphorous acid, action of reagents on	277
Platinum, oxide, action of reagents on	270
“ bichloride	248
“ crucible	177, 210
Pneumatic trough	29
Potash, action of reagents on	87, 270
“ uses of	240
“ detected	168, 188
“ impurities in	239
“ Table of specific gravities of	256
“ antimoniate	243
“ bitartrate	88
“ carbonate	240
“ chromate	242
“ nitrate	241
“ red prussiate	242
“ yellow prussiate	242
Potassium, estimation of	214
“ cyanide	242
“ ferridcyanide	242
“ ferrocyanide	242
“ iodide	241
“ and platinum, double chloride of	87
Precipitating glasses	202
Precipitates, crystalline, precautions respecting	87
“ dried	205

	PAGE
Silicic acid, detected	169, 175, 190
Silver, oxide, action of reagents on	127, 271
" detected	164, 181
" ammonio-nitrate	247
" chloride	123
" nitrate	247
" phosphate	134
Soda, action of reagents on	88, 271
" detected	168, 188
" table of specific gravities of	257
" antimoniate	89
" biborate	244
" carbonate	243
" phosphate	243
Sodium, estimation of	217
Solids, preliminary examination of	155
Solly's lamp	211
Soluble gases, preparation of	37
Solution	199
Solutions, saline, boiling points of	209
Specific gravity of solids	65
" " lighter than water	66
" insoluble powders	67
" liquids	68
" effect of temperature on	68
Stains on glass removed	50
Starch, solution of	248
Stirring rods, made	50
Strontia, action of reagents on	98, 271
" detected	168, 188
" blowpipe test for	98
Succinic acid, action of reagents on	150, 278
Sulphate of copper, analysis of	213
" " a reagent	246
" of indigo	248
" of lime	244
Sulphates, blowpipe test for	133
Sulphides, action of reagents on	140
" detected	174, 195
Sulphur, estimation of	224
Sulphuretted hydrogen, preparation of	234
" action of reagents on	140
" apparatus, tubes prepared	54
Sulphuric acid, action of reagents on	133, 277
" detected	169, 175, 190
" Table of specific gravities of	253
" estimation of	213
" uses of	232
" desiccation over	208
" impurities in	232
Sulphurous acid, action of reagents on	277
Symbols, chemical	xiv
Syphon tube, made	51

T

Table, strength of Ammonia	251
--------------------------------------	-----

	PAGE
Table, strength of Alcohol	258
“ “ Ether	259
“ “ Hydrochloric acid	255
“ “ Nitric acid	254
“ “ Potash	256
“ “ Soda	257
“ “ Sulphuric acid	253
“ Thermometrical	262
“ of freezing mixtures	260
“ showing the action of reagents on oxides and acids	265
“ showing the boiling points of saline solutions	209
“ showing the solubility of salts	264
Tartaric acid, action of reagents on	147, 278
“ uses of	237
“ impurities in	237
Test tubes, made	52
“ cleaned	xii.
Tin, detected	165, 183
“ protoxide, action of reagents on	128, 271
“ peroxide, action of reagents on	130, 271
“ protochloride, reagent	247
“ crystals of	131
Triple phosphate calculus	228
Trough, pneumatic	29
Troy weight	251
Tube distillation	161
“ glass, joined	53
Tubes, glass, hermetically sealed	56
“ for blowpipe experiments	57
“ syphon, made	51
Tungstic acid, action of reagents on	274

U

Uranium, oxide, action of reagents on	272
Urate of ammonia calculus	227
Uric acid calculus	226

V

Vanadic acid, action of reagents on	274
Vanadium, oxide, action of reagents on	272

W

Washing-bottles, tubes for	54
Washing precipitates	204
Water, estimation of in salts	214
“ formation of	37
“ distillation of	41
“ impurities of, detected	42, 249
“ distilled	249
Water blowpipe	49
Water bath	208
Weighing	200
Weights and Measures, Tables of	251
“ “ French	252

INDEX.

303

	PAGE
Wooden filtering blocks	79, 204
Working glass	50

Y

Yttria, action of reagents on	272
---	-----

Z

Zinc, oxide, action of reagents on	102, 272
“ detected	167, 173, 186
“ blowpipe test for	103
“ estimation of	218
Zirconia, action of reagents on	272

THE END.

MEDICAL BOOKS.

TO THE MEDICAL PROFESSION.

THE following list embraces works on Medical and other Sciences issued by the subscribers. They are to be met with at all the principal bookstores throughout the Union, and will be found as low in price as is consistent with the correctness of their printing, beauty of execution, illustration, and durability of binding. No prices are here mentioned, there being no fixed standard, as it is evident that books cannot be retailed at the same rate in New Orleans or Chicago as in Philadelphia. Any information, however, relative to size, cost, &c., can be had on application, free of postage, to the subscribers, or to any of the medical booksellers throughout the country.

LEA & BLANCHARD, *Philadelphia.*

DICTIONARIES, JOURNALS, &c.

AMERICAN JOURNAL OF THE MEDICAL SCIENCES, quarterly, at \$5 a year.

AN ANALYTICAL COMPEND of the various branches of Practical Medicine, Surgery, Anatomy, Midwifery, Diseases of Women and Children, Materia Medica and Therapeutics, Physiology, Chemistry and Pharmacy, by John Neill, M. D., and F. Gurney Smith, M. D., with numerous illustrations (nearly ready).

CYCLOPEDIA OF PRACTICAL MEDICINE, by Forbes, Tweedie, &c., edited by Dunglison, in 4 super royal volumes. 3154 double columned pages, strongly bound.

DUNGLISON'S MEDICAL DICTIONARY, 6th ed., 1 vol. imp. 8vo., 804 large pages, double columns.

HOBLYN'S DICTIONARY OF MEDICAL TERMS, by Hays, 1 vol. large 12mo., 402 pages, double columns.

MEDICAL NEWS AND LIBRARY, monthly, at \$1 a year.

ANATOMY.

ANATOMICAL ATLAS, by Smith and Horner, large imp. 8vo., 650 figures.

HORNER'S SPECIAL ANATOMY AND HISTOLOGY, 7th edition, 2 vols. 8vo., many cuts, 1130 pages.

HORNER'S UNITED STATES' DISSECTOR, 1 vol. large royal 12mo., many cuts, 444 pages.

QUAIN'S ELEMENTS OF ANATOMY, by Sharpey, many cuts (preparing).

WILSON'S HUMAN ANATOMY, by Goddard, 3d edition, 1 vol. 8vo., 235 woodcuts, 620 pages.

WILSON'S DISSECTOR, or Practical and Surgical Anatomy, with cuts, 1 vol. 12mo., 444 pages.

PHYSIOLOGY.

CARPENTER'S PRINCIPLES OF HUMAN PHYSIOLOGY, edited by Clymer, 1 vol. 8vo., over 300 illustrations, 3d edition, with many additions.

CARPENTER'S ELEMENTS, OR MANUAL OF PHYSIOLOGY, 1 vol. 8vo., 566 pages, many cuts.

CARPENTER'S COMPARATIVE ANATOMY AND PHYSIOLOGY, revised by the author, with beautiful engravings (preparing).

CONNECTION BETWEEN PHYSIOLOGY AND INTELLECTUAL SCIENCE, 1 vol. 18mo., paper, 23 cuts.

MEDICAL BOOKS.

CYCLOPÆDIA OF ANATOMY AND PHYSIOLOGY, based on the large work of Todd, in two vols. large 8vo., numerous cuts (preparing).

DUNGLISON'S HUMAN PHYSIOLOGY, 6th edition, 2 vols. 8vo., 1350 pages, and 370 wood-cuts.

HARRISON ON THE NERVES, 1 vol. 8vo., 292 pages.

MULLER'S PHYSIOLOGY, by Bell, 1 vol. 8vo., 686 pages.

ROGET'S OUTLINES OF PHYSIOLOGY, 8vo., 516 pages.

SOLLY ON THE HUMAN BRAIN, ITS STRUCTURE, PHYSIOLOGY, AND DISEASES (preparing).

TODD AND BOWMAN'S PHYSIOLOGICAL ANATOMY AND PHYSIOLOGY OF MAN, with numerous wood-cuts (publishing in the Medical News), to be complete in one volume.

PATHOLOGY.

ABERCROMBIE ON THE STOMACH, new edition, 1 vol. 8vo., 320 pages.

ABERCROMBIE ON THE BRAIN, new edition, 1 vol. 8vo., 324 pages.

ALISON'S OUTLINES OF PATHOLOGY, &c., 1 vol. 8vo., 420 pages.

ANDRAL ON THE BLOOD, translated by Meigs and Stillé, 1 vol. small 8vo., 120 pages.

BERZELIUS ON THE KIDNEYS AND URINE, 8vo., 180 pages.

BENNET ON THE UTERUS, 1 vol. 12mo., 146 pages.

BUDD ON THE LIVER, 1 vol. 8vo., 392 pages, plates and wood-cuts.

BILLING'S PRINCIPLES, 1 vol. 8vo., 304 pages.

BIRD ON URINARY DEPOSITS, 8vo., 228 pages, cuts.

HASSE'S PATHOLOGICAL ANATOMY, 8vo., 379 pages.

HOPE ON THE HEART, by Pennoek, a new edition, with plates, 1 vol. 8vo., 572 pages.

HUGHES ON THE LUNGS AND HEART, 1 vol. 12mo., 370 pages, with a plate.

PHILIP ON PROTRACTED INDIGESTION, 8vo. 240 pages.

PHILIP ON SCROFULA, 1 vol. 8vo., 350 pages, plates.

PROUT ON THE STOMACH AND RENAL DISEASES, 1 vol. 8vo., 466 pages, coloured plates.

RICORD ON VENEREAL, new edition, 1 vol. 8vo., 256 pages.

VÖGEL'S PATHOLOGICAL ANATOMY OF THE HUMAN BODY, 1 vol. 8vo., 536 pages, coloured plates.

WALSHE ON THE LUNGS, 1 vol. 12mo., 310 pages.

WILSON ON THE SKIN, 1 vol. 8vo., 370 pages; a new edition.

Same Work, with coloured plates.

WILLIAMS' PATHOLOGY, OR PRINCIPLES OF MEDICINE, 1 vol. 8vo., 364 pages.

WILLIAMS ON THE RESPIRATORY ORGANS, by Clymer, 1 vol. 8vo., 500 pages.

PRACTICE OF MEDICINE.

ASHWELL ON THE DISEASES OF FEMALES, by Goddard, 1 vol. 8vo., 530 pages.

BARTLETT ON THE HISTORY, DIAGNOSIS AND TREATMENT OF TYPHOID, TYPHUS, BILIOUS REMITTENT, CONGESTIVE AND YELLOW FEVER, a new and extended edition of his former work (nearly ready).

BENEDICT'S COMPENDIUM OF CHAPMAN'S LECTURES, 1 vol. 8vo., 258 pages.

CHAPMAN ON THORACIC AND ABDOMINAL VISCERA, &c., 1 vol. 8vo., 364 pages.

CHAPMAN ON FEVERS, GOUT, DROPSY, &c. &c., 1 vol. 8vo., 450 pages.

COLOMBAT DE L'ISEE ON FEMALES, translated and edited by Meigs, 1 vol. 8vo., 720 pages, cuts.

COATES' POPULAR MEDICINE, a new edition, brought up to the day, many cuts (preparing).

CONDIE ON THE DISEASES OF CHILDREN, 2d edition, 1 vol. 8vo., 658 pages.

CHURCHILL ON THE DISEASES OF FEMALES, by Huston, 4th edition, 1 vol. 8vo., 604 pages.

CHURCHILL ON THE MANAGEMENT AND MORE IMPORTANT DISEASES OF INFANCY AND CHILDHOOD (preparing).

CLYMER AND OTHERS ON FEVERS, a complete work, in 1 vol. 8vo., 600 pages.

DEWEES ON CHILDREN, 9th edition, 1 vol. 8vo., 548 pages.

DEWEES ON FEMALES, 8th edition, 1 vol. 8vo., 532 pages, with plates.

DUNGLISON'S PRACTICE OF MEDICINE, 2d edition, 2 volumes 8vo., 1322 pages.

ESQUIROL ON INSANITY, by Hunt, 8vo., 496 pages.

MEIGS ON FEMALES, in a series of Letters to his Class, with cuts (a new work, nearly ready).

THOMSON ON THE SICK ROOM, &c., 1 vol. large 12mo., 360 pages, cuts.

WATSON'S PRINCIPLES AND PRACTICE OF PHYSIC, 3d improved edition, by Condie, 1 very large vol. 8vo., over 1000 pages, strongly bound.

MEDICAL BOOKS.

SURGERY.

- BRODIE ON URINARY ORGANS**, 1 vol. 8vo., 214 pages.
- BRODIE ON THE JOINTS**, 1 vol. 8vo. 216 pages.
- BRODIE'S LECTURES ON SURGERY**, 1 vol. 8vo., 350 pages.
- BRODIE'S SELECT SURGICAL WORKS** 1 vol. 8vo., 780 pages.
- CHELIUS' SYSTEM OF SURGERY**, by South and Norris, in 3 large 8vo. vols., over 2000 pages, well bound.
- COOPER ON DISLOCATIONS AND FRACTURES**, 1 vol. 8vo., 500 pp., many cuts.
- COOPER ON HERNIA**, 1 vol. imp. 8vo., 426 pages, plates.
- COOPER ON THE TESTIS AND THYMUS GLAND**, 1 vol. imp. 8vo., many plates.
- COOPER ON THE ANATOMY AND DISEASES OF THE BREAST**, SURGICAL PAPERS, &c. &c., 1 vol. imperial 8vo., plates.
- DRUITT'S PRINCIPLES AND PRACTICE OF MODERN SURGERY**, 3d ed., 1 vol. 8vo., 534 pages, many cuts.
- DURLACHER ON CORNS, BUNIONS**, &c., 12mo., 134 pages.
- DISEASES AND SURGERY OF THE EAR**, a new and complete work (preparing).
- FERGUSON'S PRACTICAL SURGERY** 1 vol. 8vo., 2d edition, 640 pages, many cuts.
- GUTHRIE ON THE BLADDER**, 8vo., 120 pages.
- HARRIS ON THE MAXILLARY SINUS**, 8vo., 166 pages.
- JONES' (WHARTON) OPHTHALMIC MEDICINE AND SURGERY**, by Hays, 1 vol. royal 12mo., 529 pages, many cuts, and plates, plain or coloured.
- LISTON'S LECTURES ON SURGERY**, by Mütter, 1 vol. 8vo., 566 pages, many cuts.
- LAWRENCE ON THE EYE**, by Hays, new edition, much improved, 863 pages, many cuts and plates.
- LAWRENCE ON RUPTURES**, 1 vol. 8vo., 480 pages.
- MALGAIGNE'S OPERATIVE SURGERY**, with illustrations (preparing).
- MILLER'S PRINCIPLES OF SURGERY**, 1 vol. 8vo., 526 pages.
- MILLER'S PRACTICE OF SURGERY**, 1 vol. 8vo., 426 pages.

- MAURY'S DENTAL SURGERY**, 1 vol. 8vo., 286 pages, many plates and cuts.
- ROBERTSON ON THE TEETH**, 1 vol. 8vo., 220 pages, plates.
- SARGENT'S MINOR SURGERY**, 1 vol. 12mo., with cuts (preparing).

MATERIA MEDICA AND THERAPEUTICS.

- DUNGLISON'S MATERIA MEDICA AND THERAPEUTICS**, a new edition, with cuts, 2 vols. 8vo., 986 pages.
- DUNGLISON ON NEW REMEDIES**, 5th ed., 1 vol. 8vo., 653 pages.
- ELLIS' MEDICAL FORMULARY**, 8th edition, much improved, 1 vol. 8vo., 272 pages.
- GRIFFITH'S MEDICAL BOTANY**, a new and complete work, 1 large vol. 8vo., with over 350 illustrations, 704 pages.
- GRIFFITH'S UNIVERSAL FORMULARY AND PHARMACY**, a new and complete work, 1 vol. large 8vo. (at press).
- FEREIRA'S MATERIA MEDICA AND THERAPEUTICS**, by Carson, 2d ed., 2 vols. 8vo., 1580 very large pages, nearly 300 wood-cuts.
- ROYLE'S MATERIA MEDICA AND THERAPEUTICS**, by Carson, 1 vol. 8vo., 689 pages, many cuts.
- STILLE'S ELEMENTS OF GENERAL THERAPEUTICS**, a new work (preparing).
- UNIVERSAL DISPENSATORY**, with many wood-cuts, 1 vol. large 8vo. (preparing).

OBSTETRICS.

- CHURCHILL'S THEORY AND PRACTICE OF MIDWIFERY**, by Huston, 2d ed., 1 vol. 8vo., 520 pages, many cuts.
- DEWEES' SYSTEM OF MIDWIFERY**, 11th edition, 1 vol. 8vo., 600 pages, with plates.
- RIGBY'S SYSTEM OF MIDWIFERY**, 1 vol. 8vo., 492 pages.
- RAMSBOTHAM ON PARTURITION**, with many plates, 1 large vol. imperial 8vo., new and improved edition, 728 pages.

MEDICAL BOOKS.

CHEMISTRY AND HYGIENE.

- BRIGHAM ON MENTAL EXCITEMENT, &c.**, 1 vol. 12mo., 204 pages.
- DUNGLISON ON HUMAN HEALTH**, 2d edition, 8vo., 464 pages.
- FOWNE'S ELEMENTARY CHEMISTRY FOR STUDENTS**, by Bridges, 2d edition, 1 vol. royal 12mo., 460 large pages, many cuts.
- GRAHAM'S ELEMENTS OF CHEMISTRY**, 1 large vol. 8vo. (new and improved edition at press), many cuts.
- MAN'S POWER OVER HIMSELF TO PREVENT OR CONTROL INSANITY**, 18mo., paper, price 25 cents.
- PRACTICAL ORGANIC CHEMISTRY**, 18mo., paper, 25 cts.
- SIMON'S CHEMISTRY OF MAN**, 8vo., 730 pages, plates.

MEDICAL JURISPRUDENCE, EDUCATION, &c.

- BARTLETT'S PHILOSOPHY OF MEDICINE**, 1 vol. 8vo., 312 pages.
- DUNGLISON'S MEDICAL STUDENT**, 2d edition, 12mo., 312 pages.
- TAYLOR'S MEDICAL JURISPRUDENCE**, by Griffith, 1 vol. 8vo., 540 pages.
- TAYLOR'S MANUAL OF TOXICOLOGY**, edited by Griffith (at press).
- TRAILL'S MEDICAL JURISPRUDENCE**, 1 vol. 8vo., 234 pages.

NATURAL SCIENCE, &c.

- ARNOTT'S ELEMENTS OF PHYSICS**, new edition, 1 vol. 8vo., 484 pages, many cuts.
- ANSTED'S ANCIENT WORLD—POPULAR GEOLOGY**, with numerous illustrations (nearly ready).
- BIRD'S NATURAL PHILOSOPHY**, from a new London edition, 1 vol. royal 12mo., many cuts (at press).
- BREWSTER'S TREATISE ON OPTICS**, 1 vol. 12mo., 423 pages, many cuts.
- BABBAGE'S "FRAGMENT,"** 1 vol. 8vo., 250 pages.
- BUCKLAND'S GEOLOGY AND MINERALOGY**, 2 vols. 8vo., with numerous plates and maps.

- BRIDGEWATER TREATISES**, with many plates, cuts, maps, &c., 7 vols. 8vo., 3287 pages.
- CARPENTER'S ANIMAL PHYSIOLOGY**, with 300 wood-cuts (preparing).
- CARPENTER'S POPULAR VEGETABLE PHYSIOLOGY**, 1 vol. royal 12mo., many cuts.
- DANA ON CORALS**, 1 vol. royal 4to., with an atlas of plates, being vols. 8 and 9 of U. States Exploring Expedition (at press).
- DE LA BECHE'S NEW WORK ON GEOLOGY**, with wood-cuts (preparing).
- GRIFFITHS' CHEMISTRY OF THE FOUR SEASONS**, 1 vol. royal 12mo., 451 pages, many cuts.
- HALE'S ETHNOGRAPHY AND PHILOLOGY OF THE U. S. EXPLORING EXPEDITION**, in 1 large imp. 4to. vol.
- HERSCHELL'S TREATISE ON ASTRONOMY**, 1 vol. 12mo., 417 pages, numerous plates and cuts.
- INTRODUCTION TO VEGETABLE PHYSIOLOGY**, founded on the works of De Candolle, Lindley, &c., 18mo.
- KIRBY ON ANIMALS**, plates, 1 vol. 8vo., 520 pages.
- KIRBY AND SPENCE'S ENTOMOLOGY**, 1 vol. 8vo., 600 large pages; plates, plain or coloured.
- METCALF ON CALORIC**, 1 vol. large 8vo. (preparing).
- MULLER'S PRINCIPLES OF PHYSICS AND METEOROLOGY**, with five hundred and fifty wood-cuts, and two coloured plates (nearly ready).
- PHILOSOPHY IN SPORT MADE SCIENCE IN EARNEST**, 1 vol. royal 18mo., 430 pages, many cuts.
- ROGET'S ANIMAL AND VEGETABLE PHYSIOLOGY**, with 400 cuts, 2 vols. 8vo., 872 pages.
- TRIMMER'S GEOLOGY AND MINERALOGY**, 1 vol. 8vo., 528 pages, many cuts.

VETERINARY MEDICINE.

- CLATER AND SKINNER'S FARRIER**, 1 vol. 12mo., 220 pages.
- YOUATT'S GREAT WORK ON THE HORSE**, by Skinner, 1 vol. 8vo., 448 pages, many cuts.
- YOUATT AND CLATER'S CATTLE DOCTOR**, 1 vol. 12mo., 232 pages, cuts.
- YOUATT ON THE DOG**, by Lewis, 1 vol. demy 8vo., 403 pages, beautiful plates.
- YOUATT ON THE PIG**, 1 vol. 12mo., pages, beautiful plates.

NEW WORKS
AND NEW EDITIONS
 LATELY PUBLISHED BY
LEA & BLANCHARD.

MEDICAL BOOKS.

DICTIONARIES, &C.

DUNGLISON'S MEDICAL DICTIONARY, NEW EDITION, (the 7th,) much improved and enlarged, with over 6000 words not in the 6th edition. In one large octavo volume, over 900 pages, double columns. 1848.

NEILL AND SMITH'S ANALYTICAL COMPEND of Practical Medicine, Surgery, Anatomy, Midwifery, Physiology, Materia Medica and Therapeutics, and Chemistry, for the Use and Examination of Students. In one very large royal 12mo. volume, of over 900 pages, with nearly 350 wood cuts.

ANATOMY.

SHARPEY AND QUAIN'S ELEMENTS OF ANATOMY, edited by Leidy. Complete in two large octavo volumes, from the 5th London edition, with about 500 wood-cuts, (nearly ready.)

WILSON'S HUMAN ANATOMY, by Goddard, **FOURTH EDITION,** (1848,) one volume 8vo., 252 wood-cuts, 580 large pages.

PHYSIOLOGY.

KIRKES AND PAGET'S PHYSIOLOGY FOR STUDENTS, BASED ON MULLER'S LARGE WORK. In one large royal 12mo. vol., 500 pages, with 120 wood-cuts.

MATTEUCCI'S LECTURES ON THE PHYSICAL PHENOMENA OF LIVING BEINGS. Edited by Pereira. In one royal 12mo. volume, 388 pages, 36 cuts.

SOLLY ON THE ANATOMY, PHYSIOLOGY, AND PATHOLOGY OF THE BRAIN, with a Description of the Typical Form of the Brain in the Animal Kingdom. One vol. 8vo., 496 pages, 118 wood-cuts.

PATHOLOGY.

BLAKISTON'S PRACTICAL OBSERVATIONS ON CERTAIN DISEASES OF THE CHEST, and on the Principles of Auscultation. In one vol. 8vo., 384 pages.

BLOOD AND URINE, Manuals of, by Reese, Griffith, and Markwick, one vol. large 12mo., 462 pages and six plates.

BURROWS ON THE DISORDERS OF THE CEREBRAL CIRCULATION. One vol. 8vo., 216 pages, with 6 colored plates.

LALLEMAND ON SPERMATORRHEA, translated by M'Dougall. In one octavo volume, 320 pages.

WHITEHEAD ON THE CAUSES AND TREATMENT OF ABORTION AND STERILITY, being the result of an extended Practical Inquiry into the Physiological and Morbid Conditions of the Uterus. In one vol. 8vo., 368 pages.

WILLIAMS' PRINCIPLES OF MEDICINE, comprising General Pa-







